NBSIR 77-1204

Air Force Energy Conservation Handbook

Volume I -- Management Guidelines

and

Brochure - HOME ENERGY SAVINGS - Tips from Your Base Engineer

Building Environment Divison
Center for Building Technology
National Bureau of Standards
Washington, D. C. 20234

January 1977

Prepared for

Department of the Air Force
Air Force Civil Engineering Center (AFSC)
Tyndall Air Force Base, Florida 32401

U.S. AIR FORCE HANDBOOK FOR ENERGY CONSERVATION

This Handbook is prepared in two volumes and is the result of work performed by the staff of the Center for Building Technology of the National Bureau of Standards. The Program Manager was Clinton W. Phillips, Office of Housing and Building Technology, and the Project Leader and Coordinator was Douglas M. Burch, Thermal Engineering Section, Building Environment Division.

Separate sections were prepared by individuals or groups as follows:

VOLUME I. MANAGEMENT GUIDELINES. Basic document prepared under NBS contract to ENVIRO-MANAGEMENT & RESEARCH, INC., 901 8th St., N.W., Washington, D.C. Reviewed and revised by P.R.Achenbach, C. W. Phillips, F. J. Powell, and R. Jones, all of the Center for Building Technology, NBS.

Brochure HOME ENERGY SAVINGS--Tips from Your Base Engineer. Prepared by D. M. Burch and M. Reppert, with art work by Sue Dzamba. Review and comment by P. R. Achenbach, C. W. Phillips, F. J. Powell, and R. Jones.

VOLUME II. TECHNICAL GUIDELINES. Separate chapters were prepared and reviewed by staff with particular expertise in each area, as indicated:

CHAPTER 1. INTRODUCTION. Robert Jones and D. Burch, reviewed by C. W. Phillips.

CHAPTER 2. ENERGY CONSERVATION MEASURES FOR EXTERIOR BUILDING ENVELOPES. D. M. Burch and R. Baumgardner*, reviewed by F. J. Powell.

CHAPTER 3. MODIFYING MECHANICAL SYSTEMS AND OPERATING PRACTICES FOR ENERGY CONSERVATION. D.M. Burch and ENVIRO-MANAGEMENT & RESEARCH, INC.**, in consultation with R. Beausoliel, A. Camacho, J. B. Coble, D. Garbern, J. Kao, M. McNeil, and S. Treado, reviewed by R. Jones.

CHAPTER 4. CONDUCTING THE BUILDING SURVEY. R. Baumgardner*, reviewed by F. J. Powell.

CHAPTER 5. MEASUREMENTS FOR IDENTIFYING ENERGY CONSERVATION POTENTIAL. D. M. Burch, reviewed by T. Kusuda.

CHAPTER 6. THE ECONOMIC ANALYSIS. Stephen Petersen, reviewed by H. E. Marshall.

APPENDICES

A. HEAT TRANSFER FUNDAMENTALS. B. A. Peavy, reviewed by J. Hill.

B. SOLAR ENERGY SYSTEMS FOR AIR FORCE APPLICATIONS. James Hill, reviewed by T. Kusuda

C. HEAT AND CHILLED WATER DISTRIBUTION SYSTEMS. T. Kusuda, reviewed by D. M. Burch.

D. SURVEY OF COMPUTER PROGRAMS FOR EVALUATING BUILDING AND SYSTEM PERFORMANCE. William Carroll, reviewed by F. J. Powell.

E. BIBLIOGRAPHY OF ENERGY CONSERVATION DOCUMENTS. Mary Reppert.

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PREFACE

As the national energy shortage becomes more critical, the Air Force must make increasingly substantive and conspicuous efforts to conserve energy in every functional area.

In response to spiralling energy costs, the Air Force in cooperation with the National Bureau of Standards is publishing in two volumes a Handbook on Energy Conservation in existing buildings. This Handbook provides technical and management guidelines for use by management and technical personnel at the Base level.

The purpose of Volume I of the Air Force Energy Conservation Handbook is to assist Base Civil Engineering and Service Personnel in dealing with the management aspects of energy conservation. These include: establishing a management structure to implement the program, analyzing options for energy conservation in various facilities, establishing both short and long-range plans for energy management, gaining the support of all Base and tenant personnel, monitoring program progress, and related activities.

Volume II provides details primarily on technical aspects of energy conservation; that is, the specific modifications which can be made to systems and their components so energy efficiency is maximized.

The Air Force was among the first to recognize the need and potential for energy conservation through a planned program of resource management, now known as energy management. In fact, it began an energy management type of program as early as 1971, two years prior to the oil embargo which alerted most other Americans to the need to conserve. Because of its experience in the field of energy conservation, the Air Force has been able to meet its continuing goal of zero energy growth based on the 1975 energy consumption base. Simply meeting this goal is not enough, however. If the Air Force is to maximize the usefulness of its budgetary allocations, energy consumption must be reduced below 1975 levels, a task that remains to be accomplished. When this task is accomplished, the funds saved can be put to meaningful use to improve and upgrade existing facilities, helping to achieve an even higher level of efficiency in the future.

Energy management is a concept which can provide numerous benefits that are attainable on each Air Force Base.

The energy management concept holds that true energy savings are achieved not only when a system is used less, but also when the system itself is as efficient as possible. In other words, a system which wastes energy wastes it every time it is used, regardless of how much or how little. Thus, by exploring the systems involved, the number of possible ways in which energy-conserving options can be applied is expanded greatly. This, in turn, creates a great deal of flexibility, so that the energy management plan can be meshed with other ongoing operations and concerns.

Energy management pays for itself. Many of the most effective options can be implemented with an expense of nothing more than a few hours of effort. Other options may take just minimal investment. There are some options, however, which require an extensive amount of capital funding but numerous studies have shown that many of these pay for themselves in three years or less, due primarily to the continually higher cost of energy.

It must be recognized that technical matters are not the only ones involved. Numerous human concerns must also be addressed. A substantial effort must be made to involve all Base and tenant personnel to ensure that they are committed to the concept of energy management and are motivated to lend their support and cooperation by, among other things, changing habits of many years which are inherently wasteful of energy.

While no one should expect overnight miracles, following these guidelines should help to attain substantial reductions in Base energy consumption without any reduction in the standards of comfort, safety, security, and productivity which the Air Force has achieved in the past, and without having any impact whatsoever on the most important goal of all--achieving the mission.

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CHAPTER 1. INTRODUCTION

The United States always has been a land of abundant energy resources, thus enabling the nation to support a continual expansion of commerce and industry. This expansion, in turn, has been responsible for providing American citizens with the highest standard of living in the world.

As shown in Figure 1-1, the nation has come to rely most heavily upon petroleum as an energy resource. In the early 1950s, however, the nation's demand for petroleum began to outpace its supply. As a result, the United States began to import crude oil. By 1970, foreign oil accounted for 23% of domestic consumption. Although this situation had far-reaching implications, it wasn't until 1973 -- when the OPEC (Organization of Petroleum Exporting Countries) nations imposed an embargo on crude oil shipments to the U.S. -- that the danger was fully realized.

Despite the many problems created by the embargo, it served one very positive purpose. It demonstrated to all Americans that national security depends substantially on our ability to meet domestic energy needs independent of other nations.

One of the fastest and most effective ways of helping achieve the goal of energy independence is through conservation of energy.

There are two primary methods of achieving energy conservation at Air Force facilities.

The first method utilizes end-use restrictions; that is, demanding less of the systems that consume energy. Lowering thermostat settings in winter and reducing lighting requirements are examples of two common end-use restrictions. While these and similar techniques reduce energy consumption, they also may degrade human comfort and productivity, and, in some cases, safety and security as well. As such, their drawbacks can sometimes outweigh their benefits.

The second method concentrates on the efficiency of the systems which provide end-use services, with an eye toward making these systems as efficient as possible. The idea is that an inefficient system wastes energy every time it is used, no matter how much or how little, but an efficient system consumes the minimum amount of energy needed to get the job done at all times.

Shortly after imposition of the embargo, the President encouraged all Americans to conserve energy through voluntary adherence to end-use restrictions. While this conservation technique was effective in the short-term, its long-term effectiveness was limited, primarily because the number of possible end-use restrictions is limited.

Although the embargo is over, the need to conserve is not. In 1976, the U.S. still was meeting over 40% of its petroleum requirements with foreign oil. The energy conservation method being advanced today is a combination of both methods, with emphasis on maximizing efficiency.

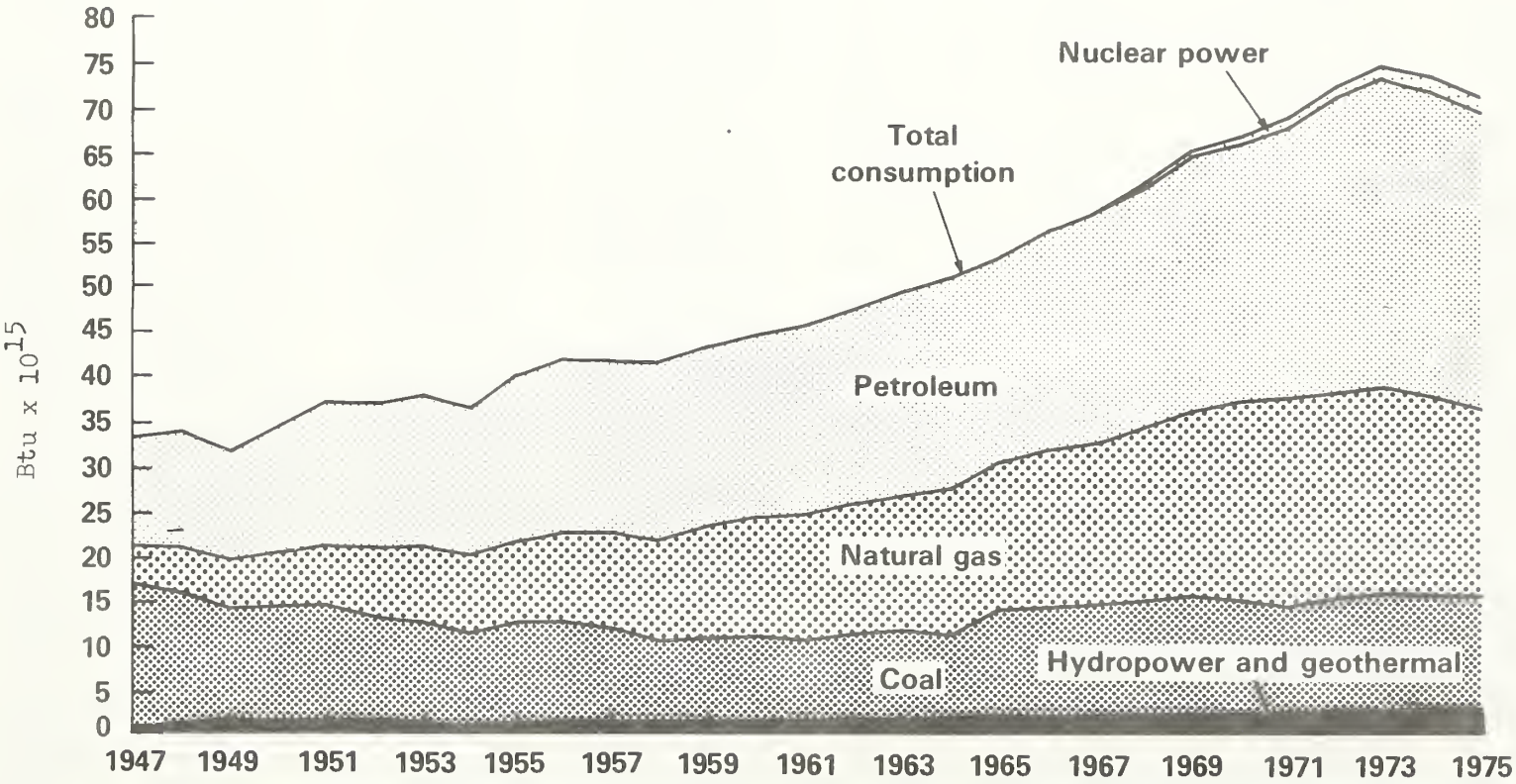


Figure 1-1. Total U. S. Energy Consumption

Source: Energy Perspectives 2 (second edition), Bureau of Mines, U.S.Dept.of Interior, June 1976.

Efficiency maximization has two primary benefits. First, it will identify many more ways to conserve. Prior to the embargo, when energy was cheap, there was no perceived need to make systems more efficient, nor could energy efficiency be justified economically. As a result, many existing systems are inherently wasteful. However, because these systems comprise so many components, and because many of these components can be modified to improve their efficiency, existing systems provide great potential for savings. In most cases, these savings can be realized through modifications which do not affect comfort, safety, security, productivity, or the ability of the Air Force to achieve its mission.

The second benefit of efficiency maximization is flexibility. Because there are so many options available, those directing the energy conservation effort are able to establish which options will be exercised first, which second, etc., so that the overall plan meshes well with other objectives that must be pursued.

Because of the great number of energy conservation options created when efficiency maximization and end-use restrictions are combined into one program, and because the order of implementing those options must be planned, the entire energy conservation program must be managed. As a result, energy conservation today is spoken of primarily as energy management. Energy management is not just another "buzzword." As the phrase implies, comprehensive management techniques must be brought to bear if the full potential for energy savings is to be realized.

Although effective application of energy management techniques will help achieve U.S. energy independence, one should not overlook the fact that energy savings can also mean energy dollar savings. On a national scale, reducing the amount of money spent on operations means that much more money available for investment in new facilities. This results in expansion, which will help achieve economic growth and economic strength.

From the point of view of the Air Force, conservation of energy dollars means a greater capability to improve existing systems and facilities and avoid the problems associated with deferred maintenance, thus enabling the Air Force to better meet its mission. Right now, however, the Air Force is being affected seriously by the high cost of energy. As shown in table 1-1, the Air Force has been able to meet its current goal of zero energy consumption growth (based on 1975 consumption), but the skyrocketing cost of energy has resulted in still greater expense. As shown, consumption in 1976 is 18.6% less than it was in 1973, but the cost for energy is almost 118% more.

TABLE 1-1. AIR FORCE ENERGY CONSUMPTION

Fiscal Year	Total A.F. Energy Consumption 10^6 Btu	Energy Costs 10^6 Dollars
1973	242	163
1974	209	185
1975	204	311
1976 (Estimate)	197	355

While one can never hope to return to the prices that prevailed in 1973 and before, the Air Force can achieve the continuing goal of zero energy growth and, with diligence and effort, even surpass that goal. In attempting to do so, however, it must be recognized that the primary goal of the Air Force is achievement of its mission. Through application of energy management, and with your help, both goals can be achieved.

CHAPTER 2. INITIATING AN ENERGY MANAGEMENT PROGRAM

Initiating an energy management program requires a team effort wherein members of the team understand the objectives of the program and are committed to achieving them.

As indicated in the previous discussion, energy management requires application of both technical and managerial skills. The purpose of Volume I is to outline management considerations. Technical requirements are detailed in Volume II.

Since 1971, the Air Force has been implementing a program for the management and conservation of utilities. The tasks performed for accomplishment of that program will be useful and applicable in this Energy Management Program.

2.1 Program Objectives

The objectives of an energy management program are to ensure that:

a. fuels and electricity are used without avoidable waste,

b. all energy-consuming systems such as heating, ventilating, cooling, hot water, internal transportation, power and other processes are operated and maintained efficiently and economically, and

c. personnel are made aware of the importance of energy conservation and the need for limiting the use of fuels and electricity to actual requirements.

2.2 Management Commitment

Commitment to the concept of energy management on the part of the Base Commander, subordinate Commanders, Civil Engineering Staff and Supervisors is essential for an effective energy management program.

There are five critical steps which the Commander should take in the beginning to ensure that the energy management program is initiated in an effective manner. These steps are:

a. Establish a clear commitment of subordinate Commanders and Supervisors to energy management.

b. Appoint a Base Energy Management Officer.

c. Delegate responsibility to the Base Energy Management Officer for implementation and management of all phases of the program.

d. Issue a policy letter on energy management.

e. Direct each Base unit to appoint a representative to the Energy Management Committee headed by the Base Energy Management Officer.

2.3 Responsibilities of the Base Energy Management Officer

Responsibility for the program should be delegated to one person: a decision-maker who understands basic energy management concepts and is capable of working closely with the various subordinate Commanders, intermediate authorities, Base tenants and Supervisors. In most cases, the Base Civil Engineer, or someone he designates from the Civil Engineering Group, should be capable of handling these responsibilities.

The specific duties of the Base Energy Management Officer include, among other things, development, implementation, monitoring, and reporting of the status and success of the energy management program. With the authority of Base Commander, he also is responsible for obtaining the cooperation of all individuals who have an impact on the energy management program.

The Base Energy Management Officer chairs the Energy Management Committee and is responsible for developing the energy management plan. Those elements of the plan which need funding above a certain level require review and approval by the Facilities Board. Other energy conservation techniques which require less funding, or no funding at all, can be implemented without Board approval.

The Base Energy Management Officer must be thoroughly familiar with the requirement of the Facilities Board and must prepare his energy management plan in light of the format and extent of detail required by the Board.

Although a substantial portion of the Energy Management Committee's work will be performed by the Base Energy Management Officer and his staff, input from all Committee members will be required if the plan is to be acceptable. For this reason, it also is the responsibility of the Base Energy Management Officer, as the chairman of the Base Energy Management Committee, to obtain commitment, cooperation, and input from all members of the Committee, and all those they represent.

2.4 Responsibilities of the Base Energy Management Committee

Once the Base Energy Management Officer is appointed, members of the Base Energy Management Committee should be chosen. It is the Committee's

responsibility to formulate a detailed energy management plan and conduct the program. The Committee could be composed of the same individuals who now serve on the Utilities Management and Conservation Committees at many Bases. Members include the Chief Engineer; the heads of Program and Planning and the Facilities Operation and Maintenance Sections of the Base Civil Engineering Group, and representatives of each tenant group.

Essential elements of the Committee's responsibilities include reviewing energy consumption data, identifying energy waste that exists, and setting specific, measurable goals to improve the efficiency with which energy is used.

The Committee should develop guidelines, which might include recommendations on surveys, record keeping, and energy conservation research. This type information becomes incorporated into an overall, detailed Base Energy Management Plan which identifies the specific technical and managerial actions which will be implemented for the first full year of the energy management program. The plan also should include information on likely options to be implemented in the two or three succeeding years. Every year, then, the Committee is able to add more detail to each succeeding year and add additional planning for years not covered in the initial plan. The initial plan and all succeeding plans must be reviewed and approved by the Facilities Board.

The Committee should meet on a periodic basis - monthly if possible - to review progress, changes to plan, etc.

2.5 Procedures

Procedures to be followed for implementing a successful Energy Management Program with the ultimate goal of conserving energy and containing costs are discussed below. More specific detail regarding each element of these procedures is provided in subsequent chapters.

2.5.1 Collecting Energy Use and Cost Data

Using utility and other records, collect data on various forms of energy used. Establish, where possible, the historical energy consumption profile of buildings and systems to identify how much energy typically is consumed and primary causes of variances. The energy use profile will help in identifying energy conservation options which can be employed. Correlations between consumption of individual units and that of the aggregate (master meter) will frequently reveal high unaccounted - for quantities of energy.

Cost data collected will provide the basis for calculating cost savings in later steps and also provide an overall sense of priority for retrofit projects.

2.5.2 Identifying Energy Conservation Opportunities

A comprehensive survey of facilities by competent persons should be made to identify facilities and systems that are large energy users, where inefficiencies exist because of poor equipment condition or because of the operating and maintenance practices being followed, etc. Although all facilities must be surveyed, those which deserve special attention include:

* buildings which are comparatively large energy consumers due to factors such as their size, special processes and equipment, etc;
* buildings which have overheating and overcooling problems;
* buildings with structural defects; and
* buildings used for purposes other than those for which they were designed.

Comprehensive information regarding the survey is provided in Chapter 3 of this Volume and in Volume II as well.

2.5.3 Analyzing Options and Establishing Priorities

After energy conservation opportunities for various facilities have been identified, analyses should be performed to determine priorities of action for retrofitting. Factors to be considered in establishing priorities include:

* energy savings potential,
* cost of implementation,
* derived benefits in terms of operation and maintenance,
* ease of modification,
* manpower and timing requirements, and
* effect on other systems.

2.5.4 Establishing the Plan

Once all options have been analyzed, it should be a relatively easy matter to identify those which deserve top priority, which the next level of priority, and so on, and -- based on timing factors -- which can be undertaken this year, next year, the year after, etc. All factors considered, it then is possible to develop a tentative timetable for the first year indicating which option will be exercised, when it will be exercised, how much it will cost, etc.

The plan must contain more than this timetable alone. It also must indicate such things as who will be responsible for compilation

of data; how the various individuals will perform their tasks; the types of communications and promotional programs that will be developed to gain the cooperation of all Base and tenant personnel, and so on.

Once all these factors and concerns are addressed and discussed, the tentative plan is complete and is ready for review by the Base Energy Management Committee. Prior to holding a Committee meeting, members should be given ample time to review the basic plan with subordinates and superiors. Because the success of the plan rests so heavily on obtaining cooperation, it is essential that any reservations expressed by Committee members be given careful consideration.

Once the Committee approves the plan, it goes to the Facilities Board for review and approval. At that point, it also becomes possible to identify a goal for the Base Energy Management Program. In essence, the goal is the sum of the energy savings which will be achieved by implementing all first-year options. In computing the goal, however, recognize that the energy to be saved in the first year depends on when the option will be implemented and the time remaining in the year.

2.5.5 Establishing an Energy Conservation Goal

Although the Air Force has set certain conservation goals in different areas, the plan should indicate the possibilities for conserving further without degrading the mission. Set conservation goals for every phase of the operation in terms of Btu's to be saved per year. Exactly how large these goals should be or how they are expressed can differ according to the situation. Whatever the goals, they should be tough, specific, measurable and feasible.

2.5.6 Implementing Conservation Actions

With the plan and goals established, the process of implementing the options identified in the plan, as well as the management tasks required to monitor these actions, report on their success, and gain Basewide commitment, cooperation and support can begin.

2.5.7 Continuing Energy Conservation Actions

The results of the program should be evaluated continually and be reported to Commanders, Supervisors and users. Solicitation of ideas from all personnel is a necessary part of the program. Everyone must be involved and motivated to produce the desired goals.

2.5.8 Evaluating Goals

The originally established energy management goal should be evaluated periodically. The results of the established program may indicate the need for program modification and the revision of the set goal.

CHAPTER 3. IDENTIFYING THE POTENTIAL FOR ENERGY CONSERVATION

To identify the potential for energy conservation on a Base, it first is necessary to conduct a comprehensive survey of all buildings and central plant systems (central heating and cooling plants). Once the survey is performed, it is analyzed to identify how and where modifications can be made to achieve energy conservation in a cost-effective manner.

3.1 Conducting the Building Survey

The Building Survey is one of the most critical elements of a Base Energy Management Program because survey findings form the foundation for the energy management plan.

The primary purpose of the survey is to identify where and why energy is consumed in and by Base buildings and central plant systems. The idea behind this approach is that, to achieve energy conservation, one first must understand how energy is consumed.

For the survey to be meaningful, it is essential that those assigned responsibilities recognize that Base buildings and central plant systems as a whole can be segregated into three separate systems which, due to their interrelationships, cause energy to be consumed. These systems are:

* Energized systems, meaning those systems which consume energy directly. These include systems and components used to provide heating, ventilation, cooling, lighting, etc., as well as pieces of equipment such as typewriters, television sets, etc.

* Non-energized systems, meaning those systems which do not consume energy, but which do impact upon the amount of energy energized systems must consume to serve a given function. Typical non-energized systems include windows, walls, roof, floors, etc.

* Human systems, meaning those persons who somehow affect the amount of energy consumed. Human systems include virtually all Base and tenant personnel, and especially those responsible for operations and maintenance.

In every case, the interrelationships of these three systems or groups of systems over a specific period of time determines the specific amount of energy which will be consumed in that period. Accordingly, a modification to any one of these three systems will modify the amount of energy consumed. For example, if the Base Energy Management Officer (human systems) instructs Base facilities maintenance personnel (human systems) to paint dark interior walls (nonenergized system) a light color to improve light reflectance characteristics in a room (nonenergized systems), it may enable reduction in the number of lamps or luminaires (energized systems)

to retain the required illumination levels for comfort and productivity (human systems). Reducing the number of lamps and/or luminaires, when performed correctly, will reduce not only lighting energy consumption and costs, but also interior heat gain. During summer months, this means cooling systems (energized systems) may have to consume less energy to maintain desired conditions.

Although conduct of the survey and analysis of findings have been broken into two separate tasks, it is obvious that those conducting the survey, such as Engineering Staff of the Base Civil Engineering Group, should be in a position of also noting opportunities for conservation as the survey is being conducted. In fact, if surveyors do not have that capability, it is probable that they also lack the capability of identifying factors essential for intelligent analysis later on.

Because proper conduct of the survey is essential to development of an overall Energy Management Program, it is essential that capable individuals be utilized. In this regard, consider utilization of outside consultants, such as consulting engineers, to conduct the survey, or critical portions of it. Because a qualified consultant generally can bring to bear years of successful experience and a comprehensive information base, he generally can perform an in-depth survey and analysis as one task, and prepare a comprehensive report on which a substantial portion of the Base Energy Management Plan can be based. In the past qualified consultants have been found with the assistance of professional organizations such as local chapters of the American Consulting Engineers Council (ACEC) or the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

Regardless of who conducts the survey, it generally is a good idea to appoint Building Monitors; that is, one person in each building who would be responsible to gather some of the data required for the survey, such as data on energy consumption (where buildings are separately metered), operating hours, number of personnel occupying buildings in after-hours operations, etc. Building Monitors become especially valuable in monitoring the program -- once it is implemented -- by providing some of the information required to evaluate progress of the program, how well building personnel are following recommended practices, etc.

Whether or not Building Monitors are used to conduct the survey, the following general steps must be taken, be it by Base personnel or outside consultants.

3.2 Building and Central Plant Systems Identification

The initial step is to identify all buildings on the Base as well as central plant systems serving these buildings. If there is insufficient manpower to survey all buildings at the same time, or within a reasonably close period of time, survey first those buildings which due to size, special processes or equipment are likely to consume large amounts of energy, and those which have over heating and over cooling, have structural defects, or which are not being used for the purposes for which they initially were designed.

For each building, the Surveyor should have on hand "as-built" architectural, mechanical and electrical drawings and specifications to familiarize himself with the building's configuration and design as well as electrical and mechanical systems and equipment layout, operation and control. If "as built" documents are not available, copies of original design drawings can be modified as necessary to indicate existing as-built conditions. If original design drawings are not available, it may be necessary to develop single-line diagrams to indicate mechanical and electrical systems installed. In addition, for each building, the surveyor should obtain:

* equipment manuals,

* operating and maintenance logs,

* energy consumption data, and

* related information.

The Surveyor also should be familiar with utility rate schedules as well as any materials which relate to any planned building modernization programs and their applications. Much of this information can be recorded in a form such as provided in Volume II.

By reviewing this information, the surveyor can get an in-depth overview of a building and the factors which cause energy consumption prior to undertaking the next step, the walk-through survey.

3.2.1 Walk-Through Survey

The walk-through survey enables the surveyor to physically inspect and, where appropriate, measure factors which affect energy consumption. (Additional information on measurement is given in Volume II.)

The items which require investigation and analysis are discussed in the following chapter. Just a quick glance indicates that some of the most critical areas include: ventilation system operation and controls and how they can be improved; airtightness of the building and how infiltration can be reduced; heating and cooling equipment including their maintenance and controls and methods of improving their efficiency; lighting and lighting levels and how they can be modified; heat-transmission characteristics and how they can be modified; occupant procedures and how they may be contributing to excessive energy consumption, and so on.

In general, it can be stated that the Surveyor could start the survey in the basement and work his way up. Assuming the equipment room is in the basement, for example, he would inspect mechanical systems and record their condition, the condition of ductwork and its insulation (or indicate that there is no insulation), etc. He would observe the performance of operating and maintenance personnel on a somewhat casual

basis (more fully through review of logs). In an office space, for example, the Surveyor would note such things as the nature of work being performed, hours of operation, location of light switches and the number of luminaires controlled by each, habits of personnel insofar as leaving lights on, opening windows are concerned, and so on.

In making the survey, an individual should utilize, in addition to typical measuring devices, either a pad and pencil to record information, or a tape recorder. It may also be worthwhile to utilize an instant development camera, and/or a slide camera to make record photos.

It is worthwhile to note that conduct of the survey depends greatly on cooperation from building operating and maintenance personnel. In this regard, it must be recognized that they may regard Surveyors actions as an evaluation of their performance. In some cases, this results in less than full cooperation for fear that findings might reflect negatively on their performance. For this reason, and especially when outside sources are utilized to conduct the survey, operating and maintenance personnel must be assured that the goal of the survey is to identify ways of making systems more efficient, and not to evaluate the performance of individuals.

Once surveys have been completed, Energy Management Personnel will have a complete record of "things as they exist now." Analysis of these data will enable formulation of a plan.

3.3 Analyzing Survey Findings

The purpose of analyzing survey findings is to identify actions which can be taken to reduce energy consumption.

If a professional was retained to perform the initial energy survey, he also should be instructed to perform the analysis. If analysis is to be performed in-house, consider these guidelines:

a. Determine where energy inefficiencies and waste now exist. This does not imply modifications to the system, but rather those actions which should be taken to bring elements of the system up to the efficiency at which they should function. This in itself can save a considerable amount of energy in most buildings.

b. If a given piece of equipment is operating poorly, determine why. Is it because it needs adjustment, repair or replacement? is not being maintained well? is being operated improperly? The cause, of course, leads directly to the cure. If poor maintenance seems to be the problem, it would mean that a revised maintenance schedule may be required, or that more instruction must be given, or that other changes may be

required. Many of the guidelines provided in Volume II will provide direction on this subject. At all times, however, consider how any change -- even bringing the system up to full operating efficiency -- will affect other elements of the same system or other systems.

c. Determine where systems can be modified in accordance with guidelines provided to achieve greater energy efficiency. In so doing, consider how the modifications should be made and what the effect will be on other systems related to it directly or indirectly.

d. Determine the problems which are likely to occur through implementation of actions, in terms of energized systems, nonenergized systems and human systems. Consideration of criteria in Code Manual AFM 88-15 is essential.

Tables 3-1, 3-2, 3-3 and 3-4* indicate in outline form some of the typical energy conservation retrofit options which are applicable to various types of Air Force buildings. These options have been grouped under the following headings: (see left margin on each form)

* ventilation and infiltration,

* heating,

* lighting,

* cooling,

* water heating, and

* miscellaneous.

The climatic zones to which each table applies are shown in Figure 3-1. Climatic variables must be accounted for because weather conditions generally determine which systems will consume most energy and, accordingly, which systems offer the greatest potential for savings. Thus, heating systems may offer significant potential for savings in facilities in Maine, but very little opportunity in Hawaii.

In each of the tables, the six factors identified above are listed in descending order of impact as determined by climatic factors.

The buildings for which typical modifications are applicable are listed in the upper right portion of each table. If there is a notation in the appropriate column, it means that a given option is feasible for the type building involved. The notations used (N, for no or low-cost; M, for minimal cost, and S, for significant cost,) indicate both feasibility and cost factors. Cost factors are provided primarily as very general guidelines.

*grouped at end of Volume I

For each modification possible, **the person(s) performing the analysis should attempt to identify:**

* the precise existing condition and the reason for modification,

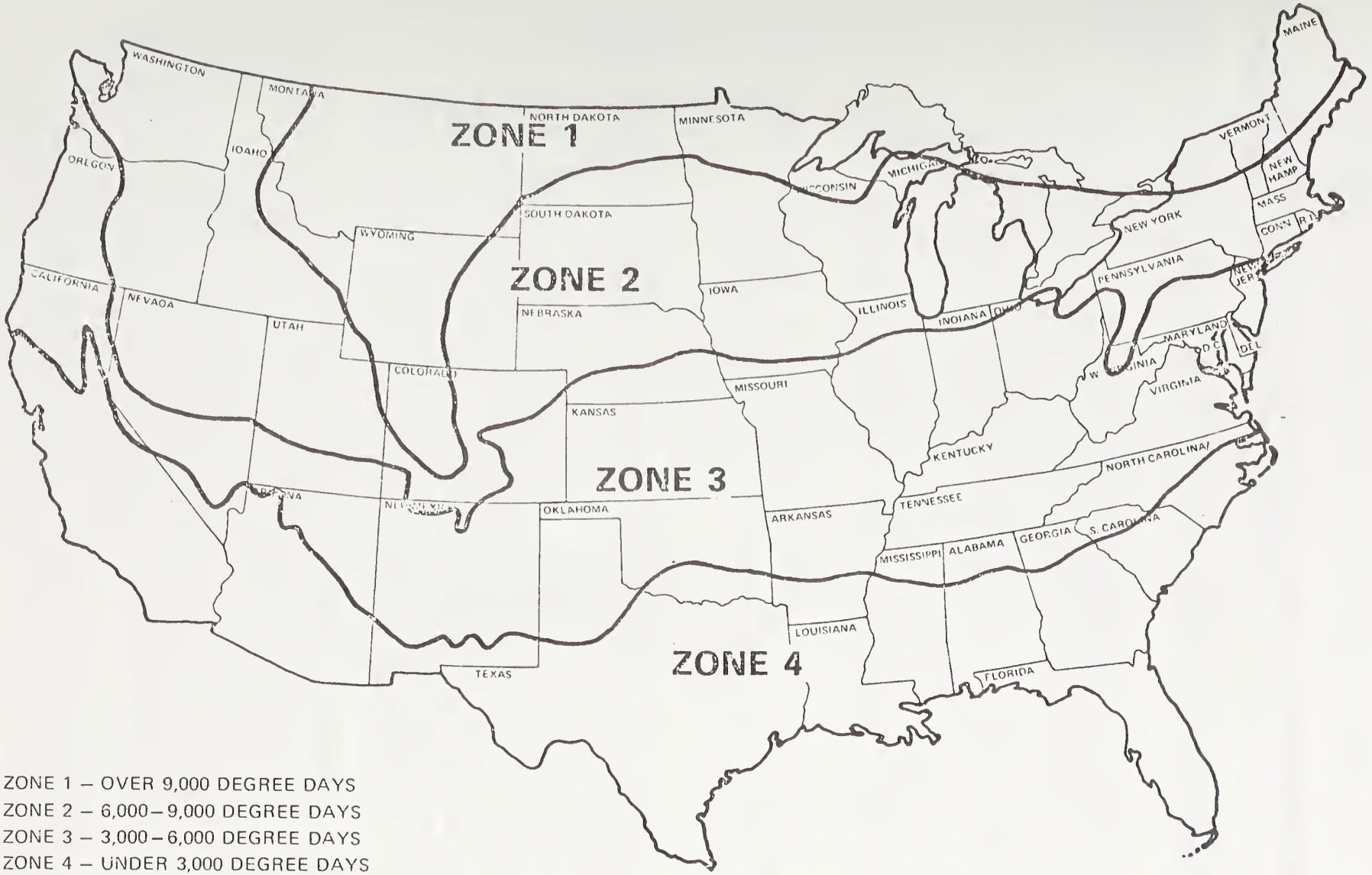
* the precise nature of the modification,

* the cost of modification,

* the **estimated amount of energy that will be saved,**

* the time required to make the modification, and

* any undesirable impact which will be created during or after the modification which will tend to **affect comfort,** productivity, safety, security, etc.



ZONE 1 – OVER 9,000 DEGREE DAYS
ZONE 2 – 6,000–9,000 DEGREE DAYS
ZONE 3 – 3,000–6,000 DEGREE DAYS
ZONE 4 – UNDER 3,000 DEGREE DAYS

NOTE: Alaska is in Zone 1 and Hawaii is in Zone 4.

Figure 3-1. U.S. climatic zones.

CHAPTER 4. ANALYZING OPTIONS AND DEVELOPING THE PLAN

At the heart of a Base Energy Management Plan is the determination of when various options are to be implemented.

In terms of an overview, consider that there are three primary types of options, defined for the purposes of this discussion as Group I, Group II, and Group III.

* Group I Options are those which can be undertaken with **little or no** cost. In many cases these options include repair items; for example, replacing broken windows, rehanging misaligned exterior doors, replacing worn insulation, etc. These options also include modifications to the system as designed, some of which can result in significant savings, such as reducing the ventilation rate. Other options relate to improving as-designed elements, for example, by adding weatherstripping or insulation where none previously existed, adding storm windows, etc. These items generally form the bulk of the options carried out in the first year, a significant portion in the second year, and continually less in future years. Usually the least costly or most effective options are implemented first.

* Group II Options are those which generally relate to improving existing systems, but at some expense. Some of those options which have very rapid payback may be implemented in the first year but, for the most part, Group II options do not get underway to any significant degree until the second year.

* Group III Options are those which involve major capital expenditures. These would include, for example, installation of heat reclamation devices, installation of demand control, use of building automation systems, etc. Because of the scope of these systems, and the generally high capital investment required, it generally is worthwhile to investigate the feasibility of each in detail. **If staff is available, the feasibility studies should be done in the first year, so the negotiations for funding to purchase the hardware required for the more cost-effective options can be initiated as early as possible. Such feasibility studies usually are conducted to provide for second year or third year implementation. However, options having an exceptionally high payback may be considered for earlier implementation.**

A suggested five-year plan showing the general relationships of these three categories of options is shown in Figure 4-1. As shown, the first year's activity is taken up primarily by implementing Group 1 options. A few Group II options are slated for that year, as are some of the Group III options. In most cases, however, the Group III work done in the first year would relate to conducting feasibility studies. As implementation of the plan progresses, more of the modifications come from Groups II and III. The most important thing to note, however, is that -- for the hypothetical case illustrated by Figure 4-1 -- attention is given to all three types of options throughout the course of the plan.

Determining specifically which particular options to undertake in a given period of time requires analysis of each option in terms of economic

and timing factors, as discussed below. Once all the suggested economic and timing analyses have been performed, it then will be possible to identify quickly which options deserve topmost priority, which second priority, etc.

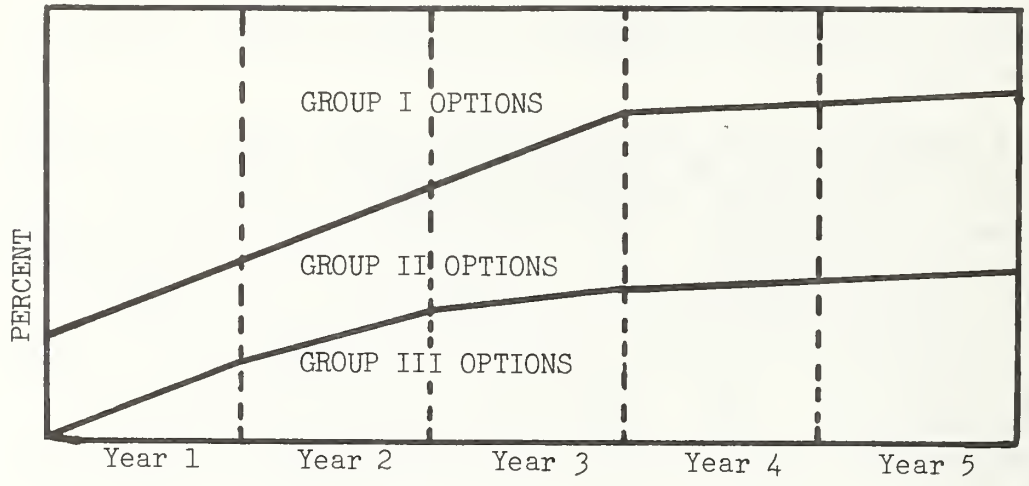


Figure 4-1. Five Year Plan

4.1 Economic Factors Analysis

An engineering and economic analysis of the survey report, assuming it was prepared as described in Chapter 3, will indicate how many energy dollars a given modification will save. Obviously, those which will save the most deserve close scrutiny.

Savings, of course, is a relative term, in that one first must consider the amount of money which must be invested to achieve the savings. In this regard, those making the analysis must utilize evaluation techniques, such as present-worth analysis, as discussed fully in Volume II. For the most part, the overriding concept in economic evaluation is life-cycle cost-benefit analysis. This concept requires that all benefits and costs incurred throughout the economic life of energy-related improvements be compared on a consistent, time-equivalent basis. The objective of this kind of analysis is to determine not only which modifications are worth doing, but the extent to which they are worth doing.

4.2 Timing Factors Analysis

Several different types of timing factors are discussed below (4.2.1 - 4.2.5). Each option must be evaluated in terms of each factor to establish the earliest date at which it could be implemented. This does not mean that an option which could be implemented tomorrow should be implemented tomorrow. It may not be a practical pursuit for another two years. But it does mean that an option which cannot be implemented for another two years obviously could not be scheduled for implementation prior to that time.

4.2.1. Manpower Factors

These relate primarily to the persons responsible for implementing the modifications. In terms of options which can be implemented by Base personnel, can they be integrated into regular routine? Will special details be required? If new operating and/or maintenance routines have to be developed, how long will development take? How much will it cost? Where will the funds come from and how long will it take to get them? Will workshops and seminars be required for personnel? How will learning new routines interfere with other duties?

4.2.2 Related-Options Factors

These refer to two or more different options that have the same specific purpose; for example, moving work stations in a space to take advantage of the installed lighting system versus modifying the installed lighting system. Obviously, it would be foolish to modify the lighting system first and move work stations second. Similarly, it would be wasteful to modify a boiler at significant expense when, due to age, it would have to be replaced in a year or two any way.

4.2.3 Funding Factors

These comprise a significant group of considerations. Each option should be identified first to determine the source of funding. Can the money required be taken from the general operating budget or will a special request have to be made? If the money will come from general funds with no special request being needed, is there enough money left in the current year's budget? next year's budget? If special funding will be required, how much time will pass between time of initial request, approval of the request, and having the funds on hand? What is the earliest data by which funding can be requested?

4.2.4 Study Time

Study time may be required, especially if the proposed option requires considerable capital expense. How long will it take to perform the study? If the study will require expense, such as the use of outside consultants, how much expense will be involved? Will a special request for study funds have to be made? If so, how long will it take for approval? If not, can funds come from the current budget? next year's?

4.2.5 Negative Impact Factors

Consider any undesirable effect which a modification may have. For the most part, these effects will occur during implementation rather than after it. For this reason, therefore, it probably would be best to modify the heating system in summer and the cooling system in winter, assuming that such modifications will cause a substantial amount of

downtime for the system involved. As mentioned earlier, any modification which in any way may hamper accomplishment of the mission requires extensive investigation before it is implemented.

4.3 Developing the Plan

Once options have been analyzed, those which are most appropriate for follow-up in the first year will immediately become obvious. Due to restraints of manpower and budget, of course, not all options which could be undertaken within the first year will be able to be undertaken. Thus, through a process of "selective weeding," those options appropriate for the first year will be identified.

The plan itself must contain more than just the possible technical changes. It should also include indications of techniques which will be employed to communicate developments and gain the commitment and cooperation of all Base and tenant personnel, as discussed in Chapter 5. Nonetheless, the technical options form the heart of the plan and must be reviewed by the Facilities Board.

Before putting the plan into written form for review by the Board, consult with its chairman -- the Base Commander or his designee -- to learn the format which the Board expects to see in order to facilitate the review and approval process. In most cases information such as that included in Chapter 3 will be necessary. This would include descriptions of modifications, energy to be saved, cost involved, etc. A summary sheet such as shown in Figure 4-2 also may be used. Once the Facilities Board approves the plan, it becomes operative.

Building	Option	Initial Costs ($)	Annual Savings (Btu)	Annual Savings ($)	Payback Period (Years)	Energy Source
#42	Preheat Combustion Air	21,000	$7,178 \times 10^6$	13,800	1.52	Oil
	Replace Worn Boiler Controls	8,750	$4,785 \times 10^6$	9,235	0.95	Oil
	Reduce Air Volume	23,000	$1,587 \times 10^6$	16,250	1.42	Electricity
	Install Automatic Thermostats	800	90×10^6	170	4.70	Oil
	Provide Lighting for Specific Tasks	8,000	254×10^6	3,200	2.50	Electricity
#11	Use more Efficient Fluorescent Lamps	54,000	$1,536 \times 10^6$	15,760	3.42	Electricity
	Reduce Air Volume	17,000	$1,024 \times 10^6$	10,500	1.62	Electricity
	Install Switching	32,000	614×10^6	6,300	5.08	Electricity

Figure 4-2. Summary of retrofit options.

CHAPTER 5. IMPLEMENTING THE BASE ENERGY MANAGEMENT PLAN

Implementing the plan involves four separate concerns: implementing the energy management options; gaining the cooperation and support of all Base and tenant personnel; monitoring the program to keep it effective; and continuing education. Since implementing the energy management options requires no further explanation, discussion here relates to the latter three concerns.

5.1 Gaining Cooperation and Support

Gaining the cooperation and support of all Base and tenant personnel comes about in two ways: by example and by communication.

The "example" method already has been mentioned, and relates directly to the commitment from above. The "communication" element bears further discussion, primarily in the form of techniques which can be used to gain the support required. In most cases,Base Public Relations Personnel can be of substantial assistance.

5.1.1 Policy Letter

As soon as the plan is established, the Base Commander should issue a policy letter indicating his own support and commitment to the energy management program, and request all other personnel to cooperate and lend assistance to whatever degree is possible. The policy letter also could include information on the nature of the program and the reasons for its establishment (such as those included in Chapter 1), as well as the goal of the program, name of the Base Energy Management Officer, etc.

5.1.2 Directives and SOP's

The Base Energy Management Officer should issue directives and Standard Operating Procedures (SOP's) which detail to various units new procedures they should follow in order to reduce energy consumption. The SOP's should have been developed jointly between the Base Energy Management Committee and those who will have to carry them out.

5.1.3 Meetings

Formal meetings can be held to explain the program in general and provide more specific information for the audience in particular. For example, a meeting could be held to explain how energy consumption can be reduced in Base residences, in dormitories, etc. Lists of suggested actions could be handed out at that time. If possible, indicate how much energy something like a lightbulb left burning needlessly for three hours wastes, and how much that waste costs. Recognize, too, that there will be informal meetings, such as in dining halls. Those

involved in implementing the Energy Management Plan should "talk up" the program, emphasizing the need for conservation and how simply conservation can be achieved.

5.1.4 News Releases

News releases usable for the Base and community news media -- including radio -- should be issued on a regular basis. Releases can cover subjects such as announcement of program establishment, appointment of the Base Energy Management Officer, etc., as well as -- on a monthly basis -- how much energy has been saved as compared with a year earlier. News releases also form a means to recognize those who make contributions of time, effort, or ideas which are truly significant. It may be desirable to prepare special news release stationery for the sole use of the Energy Management Program.

5.1.5 Public Service Advertisement

Public service advertisements can be prepared for both Base and community news media. These ads can stress energy conservation in general, or can focus on just one way to save; for example, by turning out lights when they're not needed -- "KILL-A-WATT." Print advertisements can be prepared much as any other type display ad. Radio ads can be based on a script to be read by the station announcer or by special tapes prepared by the Public Relations Officer. TV spots can comprise slides, filmstrips, film, or videotape, with soundtracks or scripts. In any event, because the advertisements are intended for the public good, the media should not charge for space or time. (Consult with media news directors, publishers, advertising managers, etc.).

5.1.6 Point-of-Use Signs

Point-of-use signs refers to small signs such as those placed over light switches which remind users of energy efficiency action. For example, a sign near an exterior door may read, "SAVE ENERGY. PLEASE BE SURE DOOR IS CLOSED SECURELY."

5.1.7 Base Consumption Signs in Buildings

An effective technique aimed at obtaining the cooperation of personnel within a given building is to provide a large chart which indicates Base energy consumption during the year and goals. Each month the new consumption figures could be posted indicating whether or not goals for the month were met.

5.1.8 Posters

Posters with the same type message as those used for public service ads can be placed throughout the Base.

5.1.9 Contests

Numerous types of contests can be conducted to heighten interest in the program. These include developing effective slogans, such

as "KILL-A-WATT" or "BT-YOU," development of logos for the program, and so on. These contests could be held among children of Base personnel, etc.

5.1.10 Suggestions

A suggestion-box program of some type could be initiated so people can send in their ideas on how to conserve energy. Good suggestions should be rewarded appropriately, reported through news releases, etc.

5.1.11 Other

Ideas for promoting the Base Energy Management Program are limited only by the human imagination. In general, however, maximum cooperation can be achieved when a note of humor is used from time to time and with good taste.

5.2 Program Monitoring and Updating

Program monitoring takes several forms. The most obvious form, of course, is through use of energy consumption data to determine how well the program is coming along in the aggregate. These data will indicate, too, how effective a given modification has been, where additional effort is required, etc.

Two other types of monitoring also are required. One type is that needed to ensure that a given modification has been made according to plans and specifications. The other involves spot-checking of personnel to determine to what degree they are cooperating, where problems are occurring, and so on.

Approximately six months into the first year of implementation of the Base Energy Management Program, the overall results of monitoring should be utilized with an eye toward underlining what changes, if any, are required for the balance of the year. At the same time, based on the results of monitoring, the plan for the second year should be established, much in the manner that the first year's plan was created.

The second-year plan should be reviewed approximately nine months into the first year to determine what changes -- if any -- should be made.

5.3 Continuing Education

In order for the gains made through a Base Energy Management Program to be sustained, continuing education is required. There are numerous seminars being conducted, for example, from which engineering staff of the Civil Engineering Group can derive great benefit. In some cases it even may be appropriate to retain firms to develop seminars specifically for Base personnel. Also, consider developing a special

library or section of a library specifically for the many new periodicals and other publications which deal with energy management and conservation.

It should be noted that a special package of materials should be developed for those who arrive on Base after the program is initiated. Many of the materials suggested above, such as directives, can be used for this purpose. New employees in the Civil Engineering Group obviously will require special indoctrination to ensure not only that they will cooperate with the goals of the Base Energy Management Program, but also that they understand specifically how they should perform a given task to ensure that high energy efficiency is maintained.

TABLES 3-1 to 3-4

indicating Energy Conservation Retrofit Options applicable to Air Force Buildings in climatic zones shown in Figure 3-1.

TABLE 3-1 CLIMATE ZONE 1 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
VENTILATION AND INFILTRATION	Shut Down Ventilation Systems During Unoccupied Periods in Noncritical Areas	N	N		N	N	N		N	
	Reduce Ventilation Rates During Unoccupied Hours to a Minimum in Noncritical Areas	N	N	N	N	N	N	N	N	N
	Optimize Ventilation Startup Times	N	N		N	N	N		N	
	Shut-off Exhaust Systems When Not Needed	N	N	N	N	N	N	N	N	N
	Eliminate All Unnecessary Exhaust Hoods and Roof Ventilators		M					M	M	M
	Replace Broken Windows	M	M	M	M	M	M	M	M	M
	Close Fireplace Dampers When Not in Use			N						
	Repair Fireplace Damper if it Does Not Seal Properly			M						
	Adjust Outdoor Air Dampers for Tight Closure	N	N		N	N	N		N	
	Reduce Infiltration Through Openings in Building Envelope	M	M	M	M	M	M	M	M	M
	Establish Rules for all Building Personnel Regarding Opening and Closing of Ext. Doors	N	N		N	N	N	N	N	N
	Install Weatherstripping Around Windows and Doors	M	M	M	M	M	M	M	M	M
	Caulk Around Window and Door Frames	M	M	M	M	M	M	M	M	M
	Install Economizer Cycle	M	M	M	M	M	M		M	
	Install Loading Dock Door Seals							M	M	M
	Rehang Misaligned Exterior Doors	M	M	M	M	M	M	M	M	M
	Install Automatic Ventilation Controls to Ensure Operation as Needed	M	M		M	M	M		M	
	Connect Ventilation Fans in Toilet Rooms to Light Circuit			M	M					
	Reduce the Quantity of Exhaust Air From Hoods		M				M			
	Consider Installation of Air Curtains					S		S	S	S
	Recover Heat from Exhaust Air to Precondition Incoming Air					S	S			
	Recirculate Exhaust Air Using Activated Charcoal Filters	S					S			
	Use Vestibules and/or Revolving Doors to Reduce Infiltration	S	S		S	S	S			
	Replace Hoods that are too Large and Which Move Excessive Quantities of Air		S				S			
	Install Automatic Door Closers on all Exterior Doors	M	M	M	M	M	M	M	M	M
HEATING	Repair all Leaks: Water, Steam, Air, Fuel, etc.	M	M	M	M	M	M	M	M	M
	Lower Indoor Temperature and Relative Humidity	N	N	N	N	N	N	N	N	N
	Add Controls to Setback Temperatures During Unoccupied Periods in Noncritical Areas	M	M	M	M	M	M	M	M	M

TABLE 3-1 CLIMATE ZONE 1 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Install Warm-up Cycle Controls on Air Handling Units With Outside Air Intake as applicable	M	M			M	M		M	
	Use Opaque or Translucent Insulating Materials to Block Off and Thermally Seal all Unused Windows		S			S		S	S	S
	Install Storm Windows	S		S	S		S			
	Add Additional Insulation to Roofs, Ceilings and Floors Over Unconditioned Areas	S	S	S	S	S	S	S	S	S
	Add Additional Insulation to Walls			S	S	S	S	S	S	S
	Consider Reglazing with Double or Triple Glazing	S	S	S	S	S	S			
	Evaluate the Necessity for Humidification; Curtail as Practical	N	N	N	N					
	Recalibrate All Controls	M	M	M	M	M	M	M	M	M
	Repair Faulty Equipment: Steam Traps, Valves, Dampers, etc.	M	M	M	M	M	M	M	M	M
	Lock Thermostats to Prevent Resetting by Unauthorized Personnel	M	M		M	M	M	M	M	M
	Reduce Heating in Overheated Spaces. Do Not Open the Window to Cool These Areas!	N	N		N					
	Turn Off or Eliminate all Portable Electric Heaters When Not Needed	N	N	N				N	N	N
	Keep Doors and Windows Closed When Heating System is Operating	N	N	N	N	N	N	N	N	N
	Repair Cracks and Openings in Exterior Surfaces	M	M	M	M	M	M	M	M	M
	Use Infra-red Television Camera System to Determine Where Heat Losses are Occurring from Buildings and Underground Distribution Piping	S	S	S	S	S	S	S	S	S
	Install and Maintain Insulation on all Hot Water Pipes, Fittings and Valves Passing Through Unconditioned Spaces	M	M	M	M	M	M		M	
	Insulate all Steam Lines; Above Ground	S	S		S	S	S	S	S	S
	Insulate all Duct Work Carrying Conditioned Air Through Unconditioned Spaces	M	M	M	M	M	M	M	M	M
	Repair Insulation on Economizers, Condensate Receiver Tanks, Boilers, Furnaces, etc.	M	M			M	M			
	Adjust Dampers in Mixing Boxes and Multi-zone Units so that they Shut-off Tight to Reduce Leakage	N	N				N			
	Vary the Steam Pressure in Accordance with Space Heating Demands	N	N							
	Reset Heating Water Temperature in Accordance with Load	N	N							
	Operate only Heating Water Pumps Necessary	N	N							

TABLE 3-1 CLIMATE ZONE 1 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost for Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Reduce Hours of Fan and Pump Operation	N	N			N	N		N	
	Operate Return Air Fans for Heating During Unoccupied Hours	N					N		N	
	Use Lowest Possible Radiation Temperature in Perimeter Spaces	N	N	N	N	N	N			
	Add Controls to Regulate Hot Deck Temperature in Accordance with Demand	M				M	M			
	Recover Heat from Condensate	S	S		S		S			
	Recover Heat from Condenser Water System	S	S							
	Install Valves and Dampers to Permit Shut-off of Heating in Unoccupied Areas Where There is no Danger of Freezing	M	M			M	M			
	Install Automatic Temperature Control Valves in Radiators Controlled by Hand Valves	S	S		S	S	S			
	Check Vents in Hot Water and Steam Systems for Proper Performance	N	N		N	N	N	N	N	N
	Keep Air Movement in and out of Radiators and Convectors Unrestricted	N	N		N	N	N			
	Provide Additional Thermostats for Better Control of Heating Equipment	S	S			S	S			
	Convert Three-way Valves to Two-way Operation and Install Variable Speed Pumping	S	S							
	Balance Water Flows to Minimally Satisfactory Levels	S	S			S	S	S	S	S
	Clean Strainer Screens in Pumping Systems	N	N		N	N	N	N	N	N
	Lower the Resistance to Flow in Duct and Piping Systems	S	S							
	Trim Pump Impeller to Match Load	M	M							
	Reduce Air Flow Rates to Minimally Satisfactory Levels	S	S							
	Adjust all Pumps to Control Leakage at Pump Packing Glands	M	M							
	Maintain all Heating Equipment and Auxiliary at Peak Efficiency	M	M	M	M	M	M	M	M	M
	Keep Filters and Heat Transfer Surfaces Clean	N	N	N	N	N	N	N	N	N
	Use Low Resistance Filters, Registers and Grilles to Reduce the Horsepower Required for Air Movement	S	S			S	S			
	Reduce Fan Speed	M	M							
	Use the Minimum Number of Boilers. It is far Better to Operate One Unit at 90 Percent Capacity Than Two at 45 Percent	N	N							
	Check Flues and Chimney for Blockages or Improper Draft Conditions	N	N	N	N	N	N	N	N	N

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(see Figure 3-1 for geographic area of zone)

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		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Clean Combustion Surfaces	N	N	N	N	N	N	N	N	N
	Seal all Air Leaks into Combustion Chamber	N	N	N	N	N	N	N	N	N
	Adjust Fuel-Air Ratio	N	N	N	N	N	N	N	N	N
	Maintain Proper Fuel Oil Temperature at Burner Tip	N	N	N	N	N	N	N	N	N
	Install Flue Gas Analyzer	S	S			S	S			
	Preheat Combustion Air With Waste Heat	S	S							
	Install Boiler Stack Economizer for Preheating Feed Water	S	S							
	Add Automatic Draft Damper Control to Reduce Heat Loss Through Breeching When the Gas or Oil Burner is Not in Operation	M	M			M	M			
	Use Proper Water Treatment to Reduce Fouling of Heat Transfer Surfaces in Boilers, Heat Exchangers, etc.	M	M	M	M	M	M	M	M	M
	Isolate Off-line Boilers	S	S							
	Reduce Blowdown Losses	M	M							
	Replace Existing Boilers Which are not at or near the end of their Useful Life with Modular Boilers	S	S							
	Install Central Supervisory Control System	S	S							
	Utilize Heat from Internal Spaces for Heating Perimeter Areas	S	S				S			
	Keep Maintenance and Operating Log of all Heating Equipment	M	M			M	M	M	M	M
	Ensure that overhead Unit Heaters Direct Heat to the Floor							N	N	N
LIGHTING	Reduce Illumination to Levels Consistent with Productivity, Safety, and Security Considerations	N	N	N	N	N	N	N	N	N
	Add Switching and Timers to Turn Off Lights When Not Needed	M	M			M	M	M	M	M
	Use Daylight for Illumination in Perimeter Areas as Practical	N	N	N	N	N	N	N	N	N
	Remove unnecessary Lamps when those Remaining Can Provide Desired Illumination	N	N	N	N	N	N	N	N	N
	Use Higher Efficiency Lamps	S	S	S	S	S	S	S	S	S
	Remove Lights Over Stacks								M	M
	Establish an Effective Lighting Usage Program	N	N	N	N	N	N	N	N	N
	Move Desks and Other Work Surfaces to a Position and Orientation that will Use Installed Luminaires to their Greatest Advantage	N	N							

TABLE 3-1 CLIMATE ZONE 1 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
LIGHTING	Revise Cleaning Schedule so Lights can be Turned Off Earlier	M	M			M	M		M	
	Add Photocell or Time Controls to Operate Outdoor Lighting	M	M	M	M	M	M	M	M	M
	Keep Lamps, Luminaires, and Interior Surfaces Clean	N	N	N	N	N	N	N	N	N
	Consider the Use of Light Colors for Walls, Floors and Ceilings to Increase Reflectance but Avoid Specular Reflections	M	M	M	M	M	M			
	Use More Efficient Ballasts	S	S			S	S	S	S	S
	Relocate Luminaires to Provide Light on Task Areas	S	S			S	S	S	S	S
	Lower Height of Lighting Fixtures	S	S			S	S	S	S	S
	Recover Heat of Light	S	S			S	S			
WATER HEATING	Repair All Leaks	M	M	M	M	M	M	M	M	M
	Reduce the Quantity of Water Used	N	N	N	N	N	N	N	N	N
	Reduce Generating and Storage Temperature Levels to the Minimum Required	N	N	N	N	N	N	N	N	N
	De-Energize Booster Heaters in Kitchens at Night		N				N			
	De-Energize Hot Water Circulating Pumps when Building is Unoccupied	N	N				N			
	Insulate Hot Bare Pipes and Storage Tanks	M	M	M	M	M	M	M	M	M
	Replace Gas Pilots with Electric Ignition Device		M	M			M			
	Avoid Using Electric Water Heater During Periods of Peak Electrical Demand	N	N	N	N	N	N	N	N	N
	Insert Orifices in Hot Water Pipes to Reduce Flow	M	M	M	M	M	M	M	M	M
	Install Efficient Nozzles and Faucets	M	M	M	M	M	M	M	M	M
	Boost Hot Water Temperature Locally		S	S	S		S			
	Recover Heat from Incinerators for Domestic Hot Water Heating		S	S						
	Recover Heat from Laundry and/or Kitchen Waste for Water Heating		S				S			
	Locate Water Heater close to the Point of Use	S	S	S	S	S	S	S	S	S
COOLING	Repair all Leaks: Chilled Water, Condenser Water, Conditioned Air, etc.	M	M	M	M	M	M	M		
	Turn Off Cooling System During Unoccupied Hours in Noncritical Areas	N	N	N		N	N	N		
	Increase Indoor Temperature and Relative Humidity Levels During Occupied Hours	N	N	N	N	N	N	N		
	Do Not Cool Lobbies, Passageways and Storage Areas to the same Degree as Work Areas	N	N	N	N	N	N	N		

TABLE 3-1 CLIMATE ZONE 1 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
COOLING	Reduce Cooling in Over-Cooled Spaces	N	N	N	N	N	N	N		
	Correct Improper Automatic Control Operation	M	M	M	M	M	M	M		
	Adjust Air Dampers for Tight Closing	N	N	N	N	N	N	N		
	Insulate Chilled Water Piping and Ductwork Located in Unconditioned Spaces	M	M	M	M	M	M			
	Use Outdoor Air for Economizer Cooling	M	M	M	M	M	M	M	M	M
	Eliminate or Reduce the Use of HVAC Systems which Require Simultaneous Heating and Cooling	M	M			M	M			
	Convert Constant-Volume Fan System to Variable Air Volume	S	S							
	Install Time Clocks on Self-Contained Cooling Units for Automatic Shutoff	M	M	M	M	M	M	M		
	Replace Inefficient Window Air Conditioners	S	S	S	S	S	S	S		
	Reduce Solar Heat Gain	M	M	M	M	M	M	M		
	Reduce Internal Heat Gain	N	N	N	N	N	N	N		
	Use Spot Cooling of People when they are Located Far Apart							S		
	Do Not Permit Perimeter and Interior Systems to Buck One Another	M	M							
	Rebalance Chilled Water and Air Distribution Systems	M	M	M	M	M	M	M		
	Raise Supply Air Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Raise Chilled Water Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Operate Condenser Water System at Lower Temperature	N	N	N	N	N	N			
	Operate Only the Chilled Water Pump and Cooling Tower Fans as Necessary	N	N	N	N	N	N			
	Trim Chilled Water Pump Impeller to Match Load	M	M							
	Use Minimum Number of Chillers. It is far Better to Operate One Unit at 90 Percent Capacity than Two at 45 Percent	N	N							
	Maintain all Cooling Equipment at Peak Efficiency	M	M	M	M	M	M	M		
	Use Proper Water Treatment to Reduce Fouling of Transfer Surfaces in Chillers and Heat Exchangers	M	M	M	M	M	M			
	Use Condenser Water for Air Conditioning Reheat	S	S							
	Check Cooling Tower Bleed-off to Ensure Water and Chemicals are not Wasted	N	N	N	N	N	N			
	Isolate Off-line Chillers	S	S							

TABLE 3-1 CLIMATE ZONE 1 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
MISCELLANEOUS	Turn Off Electrical Appliances and Machinery Not Being Used.	N	N	N	N	N	N	N	N	N
	Turn Off Snow and Ice Melting Equipment, and Heating Tapes when Not Needed	N	N			N	N			
	Improve Maintenance of Motors, Engines & Turbines	N	N	N	N	N	N	N	N	N
	Make Sure Electrical Power is not Bleeding Off to Ground	N	N	N	N	N	N	N	N	N
	Examine Elevator Usage; Shut Down Excess Capacity	N	N							
	Install Demand Limiting Equipment	S	S							
	Correct Power Factor	S	S							
	Close Off Unused Areas and Rooms	N	N	N	N	N	N	N	N	N
	Where Practical, Disconnect Refrigerated Water Fountains	N	N							
	Adjust Valves for Minimal Water Use	N	N	N	N	N	N	N	N	N
	Use Water Properly for Grounds	N	N	N	N	N	N	N	N	N
	Meter Cooling Tower Makeup Water	M	M			M	M			
	Wash and Dry Full Laundry Loads Only		N							
	Operate Exhaust Systems Installed Over Washers, Flat Work Ironers, Tumblers, etc. only when needed		N							
	Reschedule Laundry Work Hours to Avoid Peak Electrical and/or Steam Demand		N							
	Turn Off Infra-red Food Warmers when no food is being warmed		N				N			
	Preheat Ovens only for Baked Goods		N				N			
	Check Sterilizer and/or Refrigeration Equipment Doors for Proper Gasketing and Function. Repair and/or Replace as Necessary		N				N			
	Keep Refrigeration Condenser Coils Clean		N				N			
	Check all Refrigeration Systems for Correct Refrigerant Charge to Avoid Excessive Compressor Operation	N	N	N	N	N	N	N		
	Improve Maintenance of all Electrical/Mechanical Equipment	N	N	N	N	N	N	N	N	N
	Heat Recovery from Ventilation Air, Lights, Etc.	S	S			S	S			

TABLE 3-2 CLIMATE ZONE 2 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type: Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
VENTILATION AND INFILTRATION	Shut Down Ventilation Systems During Unoccupied Periods in Noncritical Areas	N	N		N	N	N		N	
	Reduce Ventilation Rates During Unoccupied Hours to a Minimum in Noncritical Areas	N	N	N	N	N	N	N	N	N
	Optimize Ventilation Startup Times	N	N		N	N	N		N	
	Shut-off Exhaust Systems When Not Needed	N	N	N	N	N	N	N	N	N
	Eliminate All Unnecessary Exhaust Hoods and Roof Ventilators		M					M	M	M
	Replace Broken Windows	M	M	M	M	M	M	M	M	M
	Close Fireplace Dampers When Not in Use			N						
	Repair Fireplace Damper if it Does Not Seal Properly			M						
	Adjust Outdoor Air Dampers for Tight Closure	N	N		N	N	N		N	
	Reduce Infiltration Through Openings in Building Envelope	M	M	M	M	M	M	M	M	M
	Establish Rules for all Building Personnel Regarding Opening and Closing of Ext. Doors	N	N		N	N	N	N	N	N
	Install Weatherstripping Around Windows and Doors	M	M	M	M	M	M	M	M	M
	Caulk Around Window and Door Frames	M	M	M	M	M	M	M	M	M
	Install Economizer Cycle	M	M	M	M	M	M		M	
	Install Loading Dock Door Seals							M	M	M
	Rehang Misaligned Exterior Doors	M	M	M	M	M	M	M	M	M
	Install Automatic Ventilation Controls to Ensure Operation as Needed	M	M		M	M	M		M	
	Connect Ventilation Fans in Toilet Rooms to Light Circuit			M	M					
	Reduce the Quantity of Exhaust Air From Hoods		M				M			
	Consider Installation of an Air Curtain					S		S	S	S
	Recover Heat from Exhaust Air to Precondition Incoming Air	S	S			S	S			
	Recirculate Exhaust Air Using Activated Charcoal Filters	S					S			
	Use Vestibules and/or Revolving Doors to Reduce Infiltration	S	S		S	S	S			
	Replace Hoods that are too Large and Which Move Excessive Quantities of Air		S				S			
	Install Automatic Door Closers on all Exterior Doors	M	M	M	M	M	M	M	M	M
HEATING	Repair all Leaks: Water, Steam, Air, Fuel, etc.	M	M	M	M	M	M	M	M	M
	Lower Indoor Temperature and Relative Humidity	N	N	N	N	N	N	N	N	N
	Add Controls to Setback Temperatures During Unoccupied Periods in Noncritical Areas	M	M	M	M	M	M	M	M	M

TABLE 3-2 CLIMATE ZONE 2 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Install Warm-up Cycle Controls on Air Handling Units With Outside Air Intake as applicable	M	M			M	M			
	Use Opaque or Translucent Insulating Materials to Block Off and Thermally Seal all Unused Windows	S	S						S	S
	Install Storm Windows			S	S		S			
	Add Additional Insulation to Roofs, Ceilings and Floors Over Unconditioned Areas	S	S	S	S	S	S	S	S	S
	Add Additional Insulation to Walls			S			S	S	S	S
	Consider Reglazing with Double or Triple Glazing	S	S	S	S		S			
	Evaluate the Necessity for Humidification; Curtail as Practical	N	N							
	Recalibrate All Controls	M	M	M	M	M	M	M	M	M
	Repair Faulty Equipment: Steam Traps, Valves, Dampers, etc.	M	M	M	M	M	M	M	M	M
	Lock Thermostats to Prevent Resetting by Unauthorized Personnel	M	M		M		M			
	Reduce Heating in Overheated Spaces. Do Not Open the Window to Cool These Areas!	N	N		N					
	Turn Off or Eliminate all Portable Electric Heaters When Not Needed	N	N	N				N	N	N
	Keep Doors and Windows Closed When Heating System is Operating	N	N	N	N	N	N	N	N	N
	Repair Cracks and Openings in Exterior Surfaces	M	M	M	M	M	M	M	M	M
	Use Infra-red Television Camera System to Determine Where Heat Losses are Occurring from Buildings and Underground Distribution Piping	S	S	S	S	S	S	S	S	S
	Install and Maintain Insulation on all Hot Water Pipes, Fittings and Valves Passing Through Unconditioned Spaces	M	M	M	M	M				
	Insulate all Steam Lines; Above and Below Ground	S	S		S	S	S	S	S	S
	Insulate all Duct Work Carrying Conditioned Air Through Unconditioned Spaces	M	M	M	M					
	Repair Insulation on Economizers, Condensate Receiver Tanks, Boilers, Furnaces, etc.	M	M							
	Adjust Dampers in Mixing Boxes and Multi-zone Units so that they Shut-off Tight to Reduce Leakage	N	N							
	Vary the Steam Pressure in Accordance with Space Heating Demands	N	N							
	Reset Heating Water Temperature in Accordance with Load	N	N							
	Operate only Necessary Heating Water Pumps	N	N							

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Reduce Hours of Fan and Pump Operation	N	N							
	Operate Return Air Fans for Heating During Unoccupied Hours	N								
	Use Lowest Possible Radiation Temperature in Perimeter Spaces	N								
	Add Controls to Regulate Hot Deck Temperature in Accordance with Demand	M								
	Recover Heat from Condensate	S	S							
	Recover Heat from Condenser Water System	S	S							
	Install Valves and Dampers to Permit Shut-off of Heating in Unoccupied Areas Where There is no Danger of Freezing	M	M							
	Install Automatic Temperature Control Valves in Radiators Controlled by Hand Valves	S	S		S					
	Check Vents in Hot Water and Steam Systems for Proper Performance	N	N		N	N	N	N	N	N
	Keep Air Movement in and out of Radiators and Convectors Unrestricted	N	N		N	N	N			
	Provide Additional Thermostats for Better Control of Heating Equipment	S	S							
	Convert Three-way Valves to Two-way Operation and Install Variable Speed Pumping	S	S							
	Balance Water Flows to Minimally Satisfactory Levels	S	S							
	Clean Strainer Screens in Pumping Systems	N	N							
	Lower the Resistance to Flow in Duct and Piping Systems	S	S							
	Trim Pump Impeller to Match Load	M	M							
	Reduce Air Flow Rates to Minimally Satisfactory Levels	S	S							
	Adjust all Pumps to Control Leakage at Pump Packing Glands	M	M							
	Maintain all Heating Equipment and Auxiliary at Peak Efficiency	M	M	M	M	M	M	M	M	M
	Keep Filters and Heat Transfer Surfaces Clean	N	N	N	N	N	N	N	N	N
	Use Low Resistance Filters, Registers and Grilles to Reduce the Horsepower Required for Air Movement	S	S							
	Reduce Fan Speed	M	M							
	Use the Minimum Number of Boilers. It is far Better to Operate One Unit at 90 Percent Capacity Than Two at 45 Percent	N	N							
	Check Flues and Chimney for Blockages or Improper Draft Conditions	N	N	N						

TABLE 3-2 CLIMATE ZONE 2 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type: Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Clean Combustion Surfaces	N	N	N	N	N	N	N	N	N
	Seal all Air Leaks into Combustion Chamber	N	N	N	N	N	N	N	N	N
	Adjust Fuel-Air Ratio	N	N	N	N	N	N	N	N	N
	Maintain Proper Fuel Oil Temperature at Burner Tip	N	N	N	N	N	N	N	N	N
	Install Flue Gas Analyzer	S	S							
	Preheat Combustion Air With Waste Heat	S	S							
	Install Boiler Stack Economizer for Preheating Feed Water	S	S							
	Add Automatic Draft Damper Control to Reduce Heat Loss Through Breeching When the Gas or Oil Burner is Not in Operation	M	M							
	Use Proper Water Treatment to Reduce Fouling of Heat Transfer Surfaces in Boilers, Heat Exchangers, etc.	M	M							
	Isolate Off-line Boilers	S	S							
	Reduce Blowdown Losses	M	M							
	Replace Existing Boilers Which are not at or near the end of their Useful Life with Modular Boilers	S	S							
	Install Central Supervisory Control System	S	S							
	Utilize Heat from Internal Spaces for Heating Perimeter Areas	S	S							
	Keep Maintenance and Operating Log of all Heating Equipment	M	M							
	Ensure that overhead Unit Heaters Direct Heat to the Floor							N	N	N
LIGHTING	Reduce Illumination to Levels Consistent with Productivity, Safety, and Security Considerations	N	N	N	N	N	N	N	N	N
	Add Switching and Timers to Turn Off Lights When Not Needed	M	M			M	M	M	M	M
	Use Daylight for Illumination in Perimeter Areas as Practical	N	N	N	N	N	N	N	N	N
	Remove unnecessary Lamps when those Remaining Can Provide Desired Illumination	N	N	N	N	N	N	N	N	N
	Use Higher Efficiency Lamps	S	S	S	S	S	S	S	S	S
	Remove Lights Over Stacks								M	M
	Establish an Effective Lighting Usage Program	N	N	N	N	N	N	N	N	N
	Move Desks and Other Work Surfaces to a Position and Orientation that will Use Installed Luminaires to their Greatest Advantage	N	N							

TABLE 3-2 CLIMATE ZONE 2 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type: Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
LIGHTING	Revise Cleaning Schedule so Lights can be Turned Off Earlier	M	M							
	Add Photocell or Time Controls To Operate Outdoor Lighting	M	M	M	M	M	M	M	M	M
	Keep Lamps, Luminaires, and Interior Surfaces Clean	N	N	N	N	N	N	N	N	N
	Consider the Use of Light Colors for Walls, Floors and Ceilings to Increase Reflectance but Avoid Specular Reflections	M	M	M	M	M	M			
	Use More Efficient Ballasts	S	S			S	S	S	S	S
	Relocate Luminaires to Provide Light on Task Areas	S	S			S	S	S	S	S
	Lower Height of Lighting Fixtures	S	S			S	S	S	S	S
	Recover Heat of Light	S	S			S	S			
COOLING	Repair all Leaks: Chilled Water, Condenser Water, Conditioned Air, etc.	M	M	M	M	M	M	M		
	Turn off Cooling System During Unoccupied Hours in Noncritical Areas	N	N	N		N	N	N		
	Increase Indoor Temperature and Relative Humidity Levels During Occupied Hours	N	N	N	N	N	N	N		
	Do Not Cool Lobbies, Passageways and Storage Areas to the same Degree as Work Areas	N	N	N	N	N	N	N		
	Reduce Cooling in Over-Cooled Spaces	N	N	N	N	N	N	N		
	Correct Improper Automatic Control Operation	M	M	M	M	M	M	M		
	Adjust Air Dampers for Tight Closing	N	N	N	N	N	N	N		
	Insulate Chilled Water Piping and Ductwork Located in Unconditioned Spaces	M	M	M	M	M				
	Use Outdoor Air for Economizer Cooling	M	M	M	M	M	M	M	M	M
	Eliminate or Reduce the Use of HVAC Systems which Require Simultaneous Heating and Cooling	M	M			M	M			
	Convert Constant-Volume Fan System to Variable Air Volume	S	S							
	Install Time Clocks on Self-Contained Cooling Units for Automatic Shutoff	M	M	M	M	M	M	M		
	Replace Inefficient Window Air Conditioners	S	S	S	S	S	S	S		
	Reduce Solar Heat Gain	M	M	M	M	M	M	M		
	Reduce Internal Heat Gain	N	N	N	N	N	N	N		
	Use Spot Cooling of People when they are Located Far Apart							S		
	Do Not Permit Perimeter and Interior Systems to Buck One Another	M	M							
	Rebalance Chilled Water and Air Distribution Systems	M	M	M	M	M	M	M		

TABLE 3-2 CLIMATE ZONE 2 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
COOLING	Raise Supply Air Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Raise Chilled Water Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Operate Condenser Water System at Lower Temperature	N	N	N						
	Operate Only the Chilled Water Pump and Cooling Tower Fans as Necessary	N	N							
	Trim Chilled Water Pump Impeller to Match Load	M	M							
	Use Minimum Number of Chillers. It is far Better to Operate One Unit at 90 Percent Capacity than Two at 45 Percent	N	N							
	Maintain all Cooling Equipment at Peak Efficiency	M	M	M	M	M	M	M		
	Use Proper Water Treatment to Reduce Fouling of Transfer Surfaces in Chillers and Heat Exchangers	M	M							
	Use Condenser Water for Air Conditioning Reheat	S	S							
	Check Cooling Tower Bleed-off to Ensure Water and Chemicals are not Wasted	N	N							
	Isolate Off-line Chillers	S	S							
WATER HEATING	Repair All Leaks	M	M	M	M	M	M	M	M	M
	Reduce the Quantity of Water Used	N	N	N	N	N	N	N	N	N
	Reduce Generating and Storage Temperature Levels to the Minimum Required	N	N	N	N	N	N	N	N	N
	De-Energize Booster Heaters in Kitchens at Night		N				N			
	De-Energize Hot Water Circulating Pumps when Building is Unoccupied	N	N							
	Insulate Hot Bare Pipes and Storage Tanks	M	M	M	M	M	M	M	M	M
	Replace Gas Pilots with Electric Ignition Device		M	M			M			
	Avoid Using Electric Water Heater During Periods of Peak Electrical Demand	N	N	N	N	N	N	N	N	N
	Insert Orifices in Hot Water Pipes to Reduce Flow	M	M	M	M	M	M	M	M	M
	Install Efficient Nozzles and Faucets	M	M	M	M	M	M	M	M	M
	Boost Hot Water Temperature Locally		S				S			
	Recover Heat from Incinerators for Domestic Hot Water Heating		S							
	Recover heat from Laundry and/or Kitchen Waste for Water Heating		S				S			
	Locate Water Heater close to the Point of Use	S	S	S	S	S	S	S	S	S

TABLE 3-2 CLIMATE ZONE 2 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

N = No Cost or Low Cost
M = Minimal Cost
S = Significant Cost

	RETROFIT OPTION	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
MISCELLANEOUS	Turn Off Electrical Appliances and Machinery Not Being Used.	N	N	N	N	N	N	N	N	N
	Turn Off Snow and Ice Melting Equipment, and Heating Tapes when Not Needed		N							
	Improve Maintenance of Motors, Engines & Turbines	N	N	N	N	N	N	N	N	N
	Make Sure Electrical Power is not Bleeding Off to Ground	N	N	N	N	N	N	N	N	N
	Examine Elevator Usage; Shut Down Excess Capacity	N	N							
	Install Demand Limiting Equipment	S	S							
	Correct Power Factor	S	S							
	Close Off Unused Areas and Rooms	N	N	N	N	N	N	N	N	N
	Where Practical, Disconnect Refrigerated Water Fountains	N	N							
	Adjust Valves for Minimal Water Use	N	N	N	N	N	N	N	N	N
	Use Water Properly for Grounds	N	N	N	N	N	N	N	N	N
	Meter Cooling Tower Makeup Water	M	M							
	Wash and Dry Full Laundry Loads Only		N							
	Operate Exhaust Systems Installed Over Washers, Flat Work Ironers, Tumblers, etc. only when needed		N							
	Reschedule Laundry Work Hours to Avoid Peak Electrical and/or Steam Demand		N							
	Turn Off Infra-red Food Warmers when no food is being warmed		N				N			
	Preheat Ovens only for Baked Goods		N				N			
	Check Sterilizer and/or Refrigeration Equipment Doors for Proper Gasketing and Function. Repair and/or Replace as Necessary		N				N			
	Keep Refrigeration Condenser Coils Clean		N				N			
	Check all Refrigeration Systems for Correct Refrigerant Charge to Avoid Excessive Compressor Operation	N	N	N	N	N	N	N		
	Improve Maintenance of all Electrical/Mechanical Equipment	N	N	N	N	N	N	N	N	N
	Heat Recovery from Ventilation Air, Lights, Etc.	S	S			S	S			

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
VENTILATION AND INFILTRATION	Shut Down Ventilation Systems During Unoccupied Periods in Noncritical Areas	N	N		N	N	N		N	
	Reduce Ventilation Rates During Unoccupied Hours to a Minimum in Noncritical Areas	N	N	N	N	N	N	N	N	N
	Optimize Ventilation Startup Times	N	N		N	N	N		N	
	Shut-off Exhaust Systems When Not Needed	N	N	N	N	N	N	N	N	N
	Eliminate All Unnecessary Exhaust Hoods and Roof Ventilators		M					M	M	M
	Replace Broken Windows	M	M	M	M	M	M	M	M	M
	Close Fireplace Dampers When Not in Use			N						
	Repair Fireplace Damper if it Does Not Seal Properly			M						
	Adjust Outdoor Air Dampers for Tight Closure	N	N		N	N	N		N	
	Reduce Infiltration Through Openings in Building Envelope	M	M	M	M	M	M	M	M	M
	Establish Rules for all Building Personnel Regarding Opening and Closing of Ext. Doors	N	N		N	N	N	N	N	N
	Install Weatherstripping Around Windows and Doors	M	M	M	M	M	M	M	M	M
	Caulk Around Window and Door Frames	M	M	M	M	M	M	M	M	M
	Install Economizer Cycle	M	M	M	M	M	M			
	Install Loading Dock Door Seals							M	M	M
	Rehang Misaligned Exterior Doors	M	M	M	M	M	M	M	M	M
	Install Automatic Ventilation Controls to Ensure Operation as Needed	M	M		M	M	M		M	
	Connect Ventilation Fans in Toilet Rooms to Light Circuit			M	M					
	Reduce the Quantity of Exhaust Air From Hoods		M				M			
	Recover Heat from Exhaust Air to Precondition Incoming Air	S	S							
	Consider Installation of an Air Curtain							S	S	S
	Recirculate Exhaust Air Using Activated Charcoal Filters	S					S			
	Use Vestibules and/or Revolving Doors to Reduce Infiltration	S	S		S	S	S			
	Replace Hoods that are too Large and Which Move Excessive Quantities of Air		S				S			
	Install Automatic Door Closers on all Exterior Doors	M	M		M	M	M	M	M	M
COOLING	Repair all Leaks: Chilled Water, Condenser Water, Conditioned Air, etc.	M	M	M	M	M	M	M		
	Turn off Cooling System During Unoccupied Hours in Noncritical Areas	N	N	N		N	N	N		

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type: Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
COOLING	Increase Indoor Temperature and Relative Humidity Levels During Occupied Hours	N	N	N	N	N	N	N		
	Do Not Cool Lobbies, Passageways and Storage Areas to the same Degree as Work Areas	N	N	N	N	N	N	N		
	Reduce Cooling in Over-Cooled Spaces	N	N	N	N	N	N	N		
	Correct Improper Automatic Control Operation	M	M	M	M	M	M	M		
	Adjust Air Dampers for Tight Closing	N	N	N	N	N	N	N		
	Insulate Chilled Water Piping and Ductwork Located in Unconditioned Spaces	M	M	M	M	M				
	Use Outdoor Air for Economizer Cooling	M	M	M	M	M	M	M	M	M
	Eliminate or Reduce the Use of HVAC Systems which Require Simultaneous Heating and Cooling	M	M			M	M			
	Convert Constant Volume Fan System to Variable Air Volume	S	S							
	Install Time Clocks on Self-Contained Cooling Units for Automatic Shutoff	M	M	M	M	M	M	M		
	Replace Inefficient Window Air Conditioners	S	S	S	S	S	S	S		
	Reduce Solar Heat Gain	M	M	M	M	M	M	M		
	Reduce Internal Heat Gain	N	N	N	N	N	N	N		
	Use Spot Cooling of People when they are Located Far Apart							S		
	Do Not Permit Perimeter and Interior Systems to Buck One Another	M	M							
	Rebalance Chilled Water and Air Distribution Systems	M	M	M	M	M	M	M		
	Raise Supply Air Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Raise Chilled Water Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Operate Condenser Water System at Lower Temperature	N	N	N						
	Operate Only the Chilled Water Pump and Cooling Tower Fans as Necessary	N	N							
	Trim Chilled Water Pump Impeller to Match Load	M	M							
	Use Minimum Number of Chillers. It is far better to Operate One unit at 90 Percent Capacity than Two at 45 Percent	N	N							
	Maintain all Cooling Equipment at Peak Efficiency	M	M	M	M	M	M	M		
	Use Proper Water Treatment to Reduce Fouling of Transfer Surfaces in Chillers and Heat Exchangers	M	M							

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type: Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
COOLING	Use Condenser Water for Air Conditioning Reheat	S	S							
	Check Cooling Tower Bleed-off to Ensure Water and Chemicals are not Wasted	N	N							
	Isolate Off-line Chillers	S	S							
HEATING	Repair all Leaks: Water, Steam, Air, Fuel, etc.	M	M	M	M	M	M	M	M	M
	Lower Indoor Temperature and Relative Humidity	N	N	N	N	N	N	N	N	N
	Add Controls to Setback Temperatures During Unoccupied Periods in Noncritical Areas	M	M	M	M	M	M	M	M	M
	Clean Combustion Surfaces	N	N	N	N	N	N	N	N	N
	Seal all Air Leaks into Combustion Chamber	N	N	N	N	N	N	N	N	N
	Adjust Fuel-Air Rating	N	N	N	N	N	N	N	N	N
	Maintain Proper Fuel Oil Temperature at Burner Tip	N	N	N	N	N	N	N	N	N
	Install Flue Gas Analyzer	S	S							
	Preheat Combustion Air With Waste Heat	S	S							
	Install Boiler Stack Economizer for Preheating Feed Water	S	S							
	Add Automatic Draft Damper Control to Reduce Heat Loss Through Breaching When the Gas or Oil Burner is Not in Operation	M	M							
	Use Proper Water Treatment to Reduce Fouling of Heat Transfer Surfaces in Boilers, Heat Exchangers, etc.	M	M							
	Isolate Off-line Boilers	S	S							
	Reduce Blowdown Losses	M	M							
	Replace Existing Boilers Which are not at or near the end of their Useful Life with Modular Boilers	S	S							
	Install Central Supervisory Control System	S	S							
	Utilize Heat from Internal Spaces for Heating Perimeter Areas	S	S							
	Keep Maintenance and Operating Log of all Heating Equipment	M	M							
	Ensure that overhead Unit Heaters Direct Heat to the Floor							N	N	N
	Install Warm-up Cycle Controls on Air Handling Units with Outside Air Intake as Applicable	M	M			M	M			
	Use Opaque or Translucent Insulating Materials to Block Off and Thermally Seal all Unused Windows	S	S						S	S
	Install Storm Windows			S	S		S			
	Add Additional Insulation to Roofs, Ceilings and Floors Over Unconditioned Areas	S	S	S	S	S	S	S	S	S

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Add Additional Insulation to Walls			S			S	S	S	S
	Consider Reglazing with Double or Triple Glazing	S	S	S	S		S			
	Evaluate the Necessity for Humidification; Curtail as Practical	N	N							
	Recalibrate All Controls	M	M	M	M	M	M	M	M	M
	Repair Faulty Equipment: Steam Traps, Valves, Dampers, etc.	M	M	M	M	M	M	M	M	M
	Lock Thermostats to Prevent Resetting by Unauthorized Personnel	M	M		M		M			
	Reduce Heating in Overheated Spaces. Do Not Open the Window to Cool These Areas!	N	N		N					
	Turn Off or Eliminate all Portable Electric Heaters When Not Needed	N	N	N				N	N	N
	Keep Doors and Windows Closed When Heating System is Operating	N	N	N	N	N	N	N	N	N
	Repair Cracks and Openings in Exterior Surfaces	M	M	M	M	M	M	M	M	M
	Use Infra-Red Television Camera System to Determine Where Heat Losses are Occurring from Buildings and Underground Distribution Piping	S	S	S	S	S	S	S	S	S
	Install and Maintain Insulation on all Hot Water Pipes, Fittings and Valves Passing Through Unconditioned Spaces	M	M	M	M	M				
	Insulate all Steam Lines, Above and Below Ground	S	S		S	S	S	S	S	S
	Insulate all Duct Work Carrying Conditioned Air Through Unconditioned Spaces	M	M	M	M					
	Repair Insulation on Economizers, Condensate Receiver Tanks, Boilers, Furnaces, etc.	M	M							
	Adjust Dampers in Mixing Boxes and Multi-zone Units so that they Shut-off Tight to Reduce Leakage	N	N							
	Vary the Steam Pressure in Accordance with Space Heating Demands	N	N							
	Reset Heating Water Temperature in Accordance with Load	N	N							
	Operate only Necessary Heating Water Pumps	N	N							
	Reduce Hours of Fan and Pump Operation	N	N							
	Operate Return-Air Fans for Heating During Unoccupied Hours	N								
	Use Lowest Possible Radiation Temperature in Perimeter Spaces	N								
	Add Controls to Regulate Hot Deck Temperature in Accordance with Demand	M								
	Recover Heat from Condensate	S	S							

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Recover Heat from Condenser Water System	S	S							
	Install Valves and Dampers to Permit Shut-off of Heating in Unoccupied Areas Where There is no Danger of Freezing	M	M							
	Install Automatic Temperature Control Valves in Radiators Controlled by Hand Valves	S	S		S					
	Check Vents in Hot Water and Steam Systems for Proper Performance	N	N		N	N	N	N	N	N
	Keep Air Movement in and out of Radiators and Convectors Unrestricted	N	N		N	N	N			
	Provide additional Thermostats for Better Control of Heating Equipment	S	S							
	Convert Three-way Valves to Two-way Operation and Install Variable Speed Pumping	S	S							
	Balance Water Flows to Minimally Satisfactory Levels	S	S							
	Clean Strainer Screens in Pumping Systems	N	N							
	Lower the Resistance to Flow in Duct and Piping Systems	S	S							
	Trim Pump Impeller to Match Load	M	M							
	Reduce Air Flow Rates to Minimally Satisfactory Levels	S	S							
	Adjust all Pumps to Control Leakage at Pump Packing Glands	M	M							
	Maintain all Heating Equipment and Auxiliary at Peak Efficiency	M	M	M	M	M	M	M	M	M
	Keep Filters and Heat Transfer Surfaces Clean	N	N	N	N	N	N	N	N	N
	Use Low Resistance Filters, Registers and Grilles to Reduce the Horsepower Required for Air Movement	S	S							
	Reduce Fan Speed	M	M							
	Use the Minimum number of Boilers. It is far Better to Operate One Unit at 90 Percent Capacity Than two at 45 Percent	N	N							
	Check Flues and Chimney for Blockages or Improper Draft Conditions	N	N	N						
LIGHTING	Reduce Illumination to Levels Consistent with Productivity, Safety, and Security Considerations	N	N	N	N	N	N	N	N	N
	Add Switching and Timers to Turn Off Lights When Not Needed	M	M			M	M	M	M	M
	Use Daylight for Illumination in Perimeter Areas as Practical	N	N	N	N	N	N	N	N	N

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
LIGHTING	Remove unnecessary Lamps when those remaining Can Provide Desired Illumination	N	N	N	N	N	N	N	N	N
	Use Higher Efficiency Lamps	S	S	S	S	S	S	S	S	S
	Remove Lights Over Stacks								M	M
	Establish an Effective Lighting Usage Program	N	N	N	N	N	N	N	N	N
	Move Desks and Other Work Surfaces to a Position and Orientation that will Use Installed Luminaires to their Greatest Advantage	N	N							
	Revise Cleaning Schedule so Lights can be Turned Off Earlier	M	M							
	Add Photocell or Time Controls To Operate Outdoor Lighting	M	M	M	M	M	M	M	M	M
	Keep Lamps, Luminaires, and Interior Surfaces Clean	N	N	N	N	N	N	N	N	N
	Consider the Use of Light Colors for Walls, Floors and Ceiling to Increase Reflectance but Avoid Specular Reflections	M	M	M	M	M	M			
	Use More Efficient Ballasts	S	S			S	S	S	S	S
	Relocate Luminaires to Provide Light on Task Areas	S	S			S	S	S	S	S
	Lower Height of Lighting Fixtures	S	S			S	S	S	S	S
	Recover Heat of Light	S	S			S	S			
WATER HEATING	Repair all Leaks	M	M	M	M	M	M	M	M	M
	Reduce the Quantity of Water Used	N	N	N	N	N	N	N	N	N
	Reduce Generating and Storage Temperature Levels to the Minimum Required	N	N	N	N	N	N	N	N	N
	De-Energize Booster Heaters in Kitchens at Night		N				N			
	De-Energize Hot Water Circulating Pumps when Building is Unoccupied	N	N							
	Insulate Hot Bare Pipes and Storage Tanks	M	M	M	M	M	M	M	M	M
	Replace Gas Pilots with Electric Ignition Device		M	M			M			
	Avoid Using Electric Water Heater During Periods of Peak Electrical Demand	N	N	N	N	N	N	N	N	N
	Insert Orifices in Hot Water Pipes to Reduce Flow	M	M	M	M	M	M	M	M	M
	Install Efficient Nozzles and Faucets	M	M	M	M	M	M	M	M	M
	Boost Hot Water Temperature Locally		S				S			
	Recover Heat from Incinerators for Domestic Hot Water Heating		S							
	Recover heat from Laundry and/or Kitchen Waste for Water Heating		S				S			
	Locate Water Heater close to the Point of Use	S	S	S	S	S	S	S	S	S

TABLE 3-3 CLIMATE ZONE 3 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
MISCELLANEOUS	Turn Off Electrical Appliances and Machinery Not Being Used.	N	N	N	N	N	N	N	N	N
	Turn Off Snow and Ice Melting Equipment, and Heating Tapes when Not Needed		N							
	Improve Maintenance of Motors, Engines & Turbines	N	N	N	N	N	N	N	N	N
	Make Sure Electrical Power is not Bleeding Off to Ground	N	N	N	N	N	N	N	N	N
	Examine Elevator Usage; Shut Down Excess Capacity	N	N							
	Install Demand Limiting Equipment	S	S							
	Correct Power Factor	S	S							
	Close Off Unused Areas and Rooms	N	N	N	N	N	N	N	N	N
	Where Practical, Disconnect Refrigerated Water Fountains	N	N							
	Adjust Valves for Minimal Water Use	N	N	N	N	N	N	N	N	N
	Use Water Properly for Grounds	N	N	N	N	N	N	N	N	N
	Meter Cooling Tower Makeup Water	M	M							
	Wash and Dry Full Laundry Loads Only		N							
	Operate Exhaust Systems Installed Over Washers, Flat Work Ironers, Tumblers, etc. only when needed		N							
	Reschedule Laundry Work Hours to Avoid Peak Electrical and/or Steam Demand		N							
	Turn Off Infra-red Food Warmers when no food is being warmed		N				N			
	Preheat Ovens only for Baked Goods		N				N			
	Check Sterilizer and/or Refrigeration Equipment Doors for Proper Gasketing and Function. Repair and/or Replace as Necessary		N				N			
	Keep Refrigeration Condenser Coils Clean		N				N			
	Check all Refrigeration Systems for Correct Refrigerant Charge to Avoid Excessive Compressor Operation	N	N	N	N	N	N	N		
	Improve Maintenance of all Electrical/Mechanical Equipment	N	N	N	N	N	N	N	N	N
	Heat Recovery from Ventilation Air, Lights, Etc.	S	S			S	S			

TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTION N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
VENTILATION AND INFILTRATION	Shut Down Ventilation Systems During Unoccupied Periods in Noncritical Areas	N	N		N	N	N		N	
	Reduce Ventilation Rates During Unoccupied Hours to a Minimum in Noncritical Areas	N	N	N	N	N	N	N	N	N
	Optimize Ventilation Startup Times	N	N		N	N	N		N	
	Shut-off Exhaust Systems When Not Needed	N	N	N	N	N	N	N	N	N
	Eliminate All Unnecessary Exhaust Hoods and Roof Ventilators		M					M	M	M
	Replace Broken Windows	M	M	M	M	M	M	M	M	M
	Close Fireplace Dampers When Not in Use			N						
	Repair Fireplace Damper if it Does Not Seal Properly			M						
	Adjust Outdoor Air Dampers for Tight Closure	N	N		N	N	N		N	
	Reduce Infiltration Through Openings in Building Envelope	M	M	M	M	M	M	M	M	M
	Establish Rules for all Building Personnel Regarding Opening and Closing of Ext. Doors	N	N		N	N	N	N	N	N
	Install Weatherstripping Around Windows and Doors	M	M	M	M	M	M	M	M	M
	Caulk Around Window and Door Frames	M	M	M	M	M	M	M	M	M
	Install Economizer Cycle	M	M	M	M	M	M			
	Install Loading Dock Door Seals							M	M	M
	Rehang Misaligned Exterior Doors	M	M	M	M	M	M	M	M	M
	Install Automatic Ventilation Controls to Ensure Operation as Needed	M	M		M	M	M		M	
	Connect Ventilation Fans in Toilet Rooms to Light Circuit			M	M					
	Reduce the Quantity of Exhaust Air from Hoods		M				M			
	Recover Heat from Exhaust Air to Precondition Incoming Air	S	S							
	Recirculate Exhaust Air Using Activated Charcoal Filters	S					S			
	Use Vestibules and/or Revolving Doors to Reduce Infiltration	S	S		S	S	S			
	Replace Hoods that are too Large and Which Move Excessive Quantities of Air		S				S			
	Install Automatic Door Closers on all Exterior Doors	M	M	M	M	M	M	M	M	M
COOLING	Repair all Leaks: Chilled Water Condenser Water, Conditioned Air, etc.	M	M	M	M	M	M	M		
	Turn off Cooling System During Unoccupied Hours in Noncritical Areas	N	N	N	N	N	N	N		

TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
COOLING	Increase Indoor Temperature and Relative Humidity Levels During Occupied Hours	N	N	N	N	N	N	N		
	Do Not Cool Lobbies, Passageways and Storage Areas to the same Degree as Work Areas	N	N	N	N	N	N	N		
	Reduce Cooling in Over-Cooled Spaces	N	N	N	N	N	N	N		
	Correct Improper Automatic Control Operation	M	M	M	M	M	M	M		
	Adjust Air Dampers for Tight Closing	N	N	N	N	N	N	N		
	Insulate Chilled Water Piping and Ductwork Located in Unconditioned Spaces	M	M	M	M	M				
	Use Outdoor Air for Economizer Cooling	M	M	M	M	M	M	M	M	M
	Eliminate or Reduce the Use of HVAC Systems which Require Simultaneous Heating and Cooling	M	M			M	M			
	Convert Constant-Volume Fan System to Variable Air Volume	S	S							
	Install Time Clocks on Self-Contained Cooling Units for Automatic Shutoff	M	M	M	M	M	M	M		
	Replace Inefficient Window Air Conditioners	S	S	S	S	S	S	S		
	Reduce Solar Heat Gain	M	M	M	M	M	M	M		
	Reduce Internal Heat Gain	N	N	N	N	N	N	N		
	Install Cool-Down Cycle Controls on Air Handling Units With Outside Air Intake as applicable	M	M			M	M			
	Use spot cooling of people when they are located far apart.									
	Do Not Permit Perimeter and Interior Systems to Buck One Another	M	M							
	Rebalance Chilled Water and Air Distribution Systems	M	M	M	M	M	M	M		
	Raise Supply Air Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Raise Chilled Water Temperature in Accordance with Load	N	N	N	N	N	N	N		
	Operate Condenser Water System at Lower Temperature	N	N	N						
	Operate Only the Chilled Water Pump and Cooling Tower Fans as Necessary	N	N							
	Adjust Dampers in Mixing Boxes and Multi-zone Units so that they Shut-off Tight to Reduce Leakage	N	N							
	Lock Thermostats to Prevent Resetting by Unauthorized Personnel	M	M		M		M			
	Maintain all Cooling Equipment at Peak Efficiency	M	M	M	M	M	M	M		
	Use Proper Water Treatment to Reduce Fouling of Transfer Surfaces in Chillers and Heat Exchangers	M	M							

TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
COOLING	Clean Strainer Screens in Pumping Systems	N	N							
	Lower the Resistance to Flow in Duct and Piping Systems	S	S							
	Reduce Air Flow Rates to Minimally Satisfactory Levels	S	S							
	Adjust all Pumps to Control Leakage at Pump Packing Glands	M	M							
	Keep Filters and Heat Transfer Surfaces Clean	N	N	N	N	N	N	N	N	N
	Use Low Resistance Filters, Registers and Grills to Reduce the Horsepower Required for Air Movement	S	S							
	Reduce Fan Speed	M	M							
	Trim Chilled Water Pump Impeller to Match Load	M	M							
	Use Minimum Number of Chillers. It is far Better to Operate One Unit at 90 Percent Capacity than Two at 45 Percent	N	N							
	Install Central Supervisory Control System	S	S							
	Use Condenser Water for Air Conditioning Reheat	S	S							
	Convert Three-way Valves to Two-way Operation and Install Variable Speed Pumping	S	S							
	Check Cooling Tower Bleed-off to Ensure Water and Chemicals are not Wasted	N	N							
	Isolate Off-line Chillers	S	S							
LIGHTING	Reduce Illumination to Levels Consistent with Productivity, Safety, and Security Considerations	N	N	N	N	N	N	N	N	N
	Add Switching and Timers to Turn Off Lights When Not Needed	M	M			M	M	M	M	M
	Use Daylight for Illumination in Perimeter Areas as Practical	N	N	N	N	N	N	N	N	N
	Remove Unnecessary Lamps when those Remaining Can Provide Desired Illumination	N	N	N	N	N	N	N	N	N
	Use Higher Efficiency Lamps	S	S	S	S	S	S	S	S	S
	Remove Lights Over Stacks								M	M
	Establish an Effective Lighting Usage Program	N	N	N	N	N	N	N	N	N
	Move Desks and Ohter Work Surfaces to a Position and Orientation that will Use Installed Luminaires to their Greatest Advantage	N	N							

TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
LIGHTING	Revise Cleaning Schedule so Lights can be Turned Off Earlier	M	M							
	Add Photocell or Time Controls To Operate Outdoor Lighting	M	M	M	M	M	M	M	M	M
	Keep Lamps, Luminaires, and Interior Surfaces Clean	N	N	N	N	N	N	N	N	N
	Consider the Use of Light Colors for Walls, Floors and Ceilings to Increase Reflectance but Avoid Specular Reflections	M	M	M	M	M	M			
	Use More Efficient Ballasts	S	S			S	S	S	S	S
	Relocate Luminaires to Provide Light on Task Areas	S	S			S	S	S	S	S
	Lower Height of Lighting Fixtures	S	S			S	S	S	S	S
	Recover Heat of Light	S	S			S	S	S	S	S
HEATING	Repair all Leaks: Water, Steam, Air, Fuel, etc.	M	M	M	M	M	M	M	M	M
	Lower Indoor Temperature and Relative Humidity	N	N	N	N	N	N	N	N	N
	Add Controls to Setback Temperatures During Unoccupied Periods in Noncritical Areas	M	M	M	M	M	M	M	M	M
	Evaluate the Necessity for Humidification; Curtail as Practical	N	N							
	Recalibrate All Controls	M	M	M	M	M	M	M	M	M
	Repair Faulty Equipment: Steam Traps, Valves, Dampers, etc.	M	M	M	M	M	M	M	M	M
	Reduce Heating in Overheated Spaces. Do Not Open the Window to Cool These Areas!	N	N		N					
	Turn Off or Eliminate all Portable Electric Heaters When Not Needed	N	N	N				N	N	N
	Keep Doors and Windows Closed When Heating System is Operating	N	N	N	N	N	N	N	N	N
	Repair Cracks and Openings in Exterior Surfaces	M	M	M	M	M	M	M	M	M
	Use Intra-red Television Camera System to Determine Where Heat Losses are Occurring from Buildings and Underground Distribution Piping	S	S	S	S	S	S	S	S	S
	Install and Maintain Insulation on all Hot Water Pipes, Fittings and Valves Passing Through Unconditioned Spaces	M	M	M	M	M				
	Insulate all Steam Lines, Above and below Ground	S	S		S	S	S	S	S	S
	Insulate all Duct Work Carrying Conditioned Air Through Unconditioned Spaces	M	M	M	M					
	Repair Insulation on Economizers, Condensate Receiver Tanks, Boilers, Furnaces, etc.	M	M							

TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

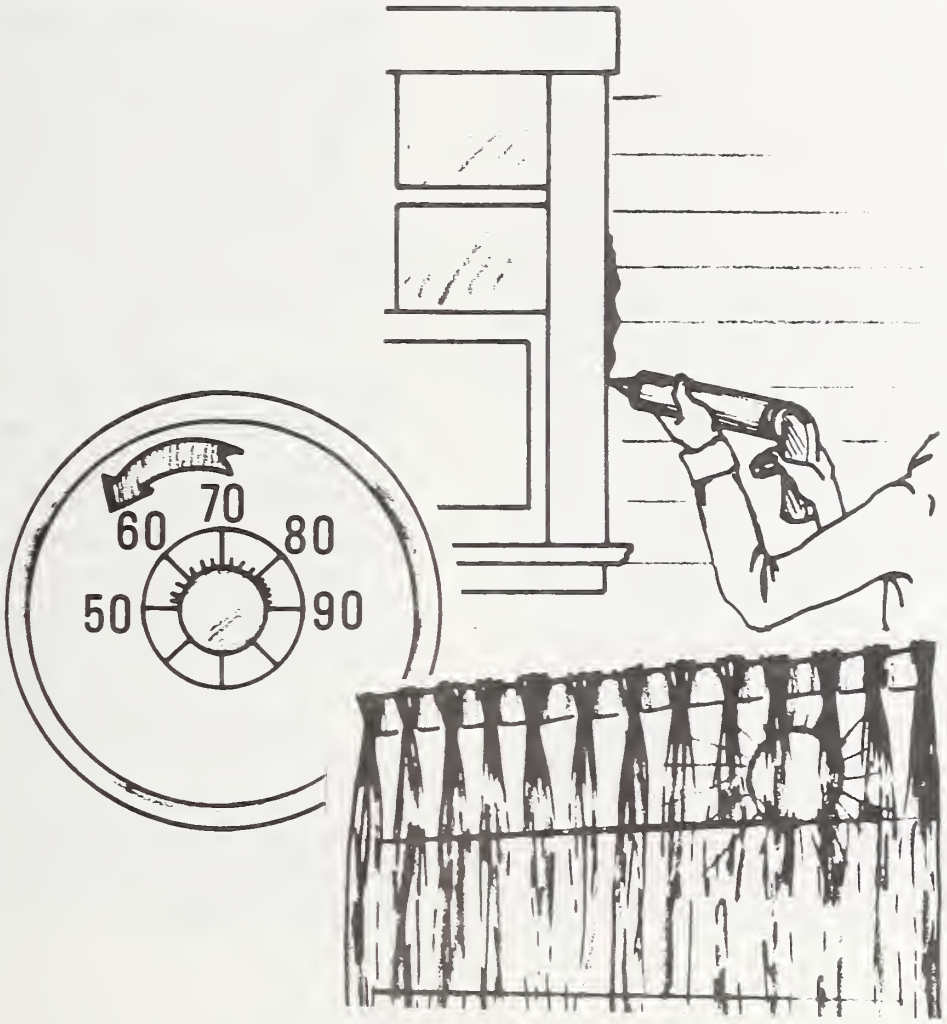
	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Vary the Steam Pressure in Accordance with Space Heating Demands	N	N							
	Reset Heating Water Temperature in Accordance with Load	N	N							
	Operate only Necessary Heating Water Pumps	N	N							
	Reduce Hours of Fan and Pump Operation	N	N							
	Operate Return Air Fans for Heating During Unoccupied Hours	N								
	Use Lowest Possible Radiation Temperature in Perimeter Spaces	N								
	Add Controls to Regulate Hot Deck Temperature in Accordance with Demand	M								
	Recover Heat from Condensate	S	S							
	Recover Heat from Condenser Water System	S	S							
	Install Valves and Dampers to Permit Shut-off of Heating in Unoccupied Areas Where There is no Danger of Freezing	M	M							
	Install Automatic Temperature Control Valves in Radiators Controlled by Hand Valves	S	S		S					
	Check Vents in Hot Water and Steam Systems for Proper Performance	N	N		N	N	N	N	N	N
	Keep Air Movement in and out of Radiators and Convectors Unrestricted	N	N		N	N	N			
	Provide Additional Thermostats for Better Control of all Heating Equipment	S	S							
	Balance Water Flows to Minimally Satisfactory Levels	S	S							
	Trim Pump Impeller to Match Load	M	M							
	Maintain all Heating Equipment and Auxiliary at Peak Efficiency	M	M	M	M	M	M	M	M	M
	Use the Minimum number of Boilers. It is far Better to Operate One Unit at 90 Percent Capacity Than Two at 45 Percent	N	N							
	Check Flues and Chimney for Blockages or Improper Draft Conditions	N	N	N						
	Clean Combustion Surfaces	N	N	N	N	N	N	N	N	N
	Seal all Air Leaks into Combustion Chamber	N	N	N	N	N	N	N	N	N
	Adjust Fuel-Air Ratio	N	N	N	N	N	N	N	N	N
	Maintain Proper Fuel Oil Temperature at Burner Tip	N	N	N	N	N	N	N	N	N
	Install Flue Gas Analyzer	S	S							
	Preheat Combustion Air With Waste Heat	S	S							

TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
HEATING	Utilize Heat from Internal Spaces for Heating Perimeter Areas	S	S							
	Keep Maintenance and Operating Log of all Heating Equipment	M	M							
	Ensure that Overhead Unit Heaters Direct Heat to the Floor							N	N	N
	Install Boiler Stack Economizer for Preheating Feed Water	S	S							
	Add Automatic Draft Damper Control to Reduce Heat Loss Through Breeching When the Gas or Oil Burner is Not in Operation	M	M							
	Use Proper Water Treatment to Reduce Fouling of Heat Transfer Surfaces in Boilers, Heat Exchangers, etc.	M	M							
	Isolate Off-line Boilers	S	S							
	Reduce Blowdown Losses	M	M							
	Replace Existing Boilers Which are not at or near the end of their Useful Life with Modular Boilers	S	S							
WATER HEATING	Repair All Leaks	M	M	M	M	M	M	M	M	M
	Reduce the Quantity of Water Used	N	N	N	N	N	N	N	N	N
	Reduce Generating and Storage Temperature Levels to the Minimum Required	N	N	N	N	N	N	N	N	N
	De-Energize Booster Heaters in Kitchens at Night		N				N			
	De-Energize Hot Water Circulating Pumps when Building is Unoccupied	N	N							
	Insulate Hot Bare Pipes and Storage Tanks	M	M	M	M	M	M	M	M	M
	Replace Gas Pilots with Electric Ignition Device		M	M			M			
	Avoid Using Electric Water Heater During Periods of Peak Electrical Demand	N	N	N	N	N	N	N	N	N
	Insert Orifices in Hot Water Pipes to Reduce Flow	M	M	M	M	M	M	M	M	M
	Install Efficient Nozzles and Faucets	M	M	M	M	M	M	M	M	M
	Boost Hot Water Temperature Locally		S				S			
	Recover Heat from Incinerators for Domestic Hot Water Heating		S							
	Recover Heat from Laundry and/or Kitchen Waste for Water Heating		S				S			
	Locate Water Heater close to the point of use	S	S	S	S	S	S	S	S	S
	Turn Off Electrical Appliances and Machinery Not Being Used.	N	N	N	N	N	N	N	N	N
	Turn Off Snow and Ice Melting Equipment, and Heating Tapes when Not Needed		N							

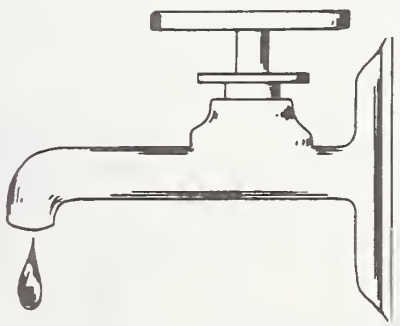
TABLE 3-4 CLIMATE ZONE 4 ENERGY CONSERVATION OPTIONS
(see Figure 3-1 for geographic area of zone)

	RETROFIT OPTIONS N = No Cost or Low Cost M = Minimal Cost S = Significant Cost	Building Type								
		Offices	Hospitals	Family Housing	Dormitories	Commissaries	Dining Halls	Hangars	Maintenance Fac.	Warehouses
MISCELLANEOUS	Improve Maintenance of Motors, Engines & Turbines	N	N	N	N	N	N	N	N	N
	Make Sure Electrical Power is not Bleeding Off to Ground	N	N	N	N	N	N	N	N	N
	Examine Elevator Usage; Shut Down Excess Capacity	N	N							
	Install Demand Limiting Equipment	S	S							
	Correct Power Factor	S	S							
	Close Off Unused Areas and Rooms	N	N	N	N	N	N	N	N	N
	Where Practical, Disconnect Refrigerated Water Fountains	N	N							
	Adjust Valves for Minimal Water Use	N	N	N	N	N	N	N	N	N
	Use Water Properly for Grounds	N	N	N	N	N	N	N	N	N
	Meter Cooling Tower Makeup Water	M	M							
	Wash and Dry Full Laundry Loads Only		N							
	Operate Exhaust Systems Installed Over Washers, Flat Work Ironers, Tumblers, etc. only when needed		N							
	Reschedule Laundry Work Hours to Avoid Peak Electrical and/or Steam Demand		N							
	Turn Off Intra-red Food Warmers when no food is being warmed		N				N			
	Preheat Ovens only for Baked Goods		N				N			
	Check Sterilizer and/or Refrigeration Equipment Doors for Proper Gasketing and Function Repair and/or Replace as Necessary		N				N			
	Keep Refrigeration Condenser Coils Clean		N				N			
	Check all Refrigeration Systems for Correct Refrigerant Charge to Avoid Excessive Compressor Operation	N	N	N	N	N	N	N		
	Improve Maintenance of all Electrical/Mechanical Equipment	N	N	N	N	N	N	N	N	N
	Heat Recovery from Ventilation Air, Lights, Etc.	S	S			S	S			



Home Energy Savings

TIPS FROM YOUR BASE CIVIL ENGINEER



Prepared by the National Bureau of Standards

INTRODUCTION

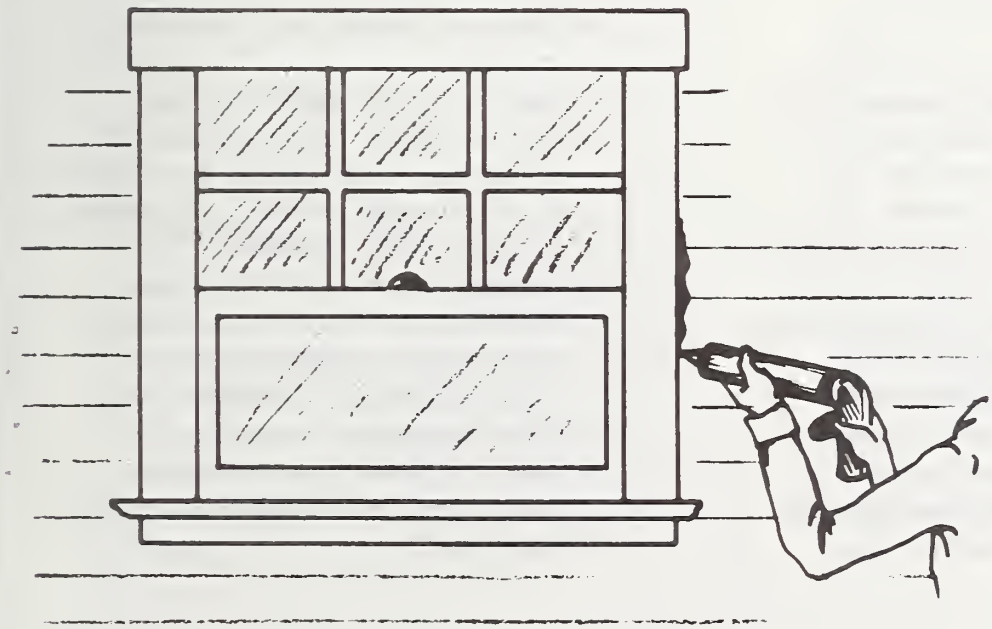
Air Force dollars spent for energy have been increasing rapidly. Even though the Air Force has taken steps to reduce energy consumption, the rise in fuel prices has substantially offset any gains from reduction of consumption. Practice energy conservation in your home and you can help your Air Force ease demands and reduce its energy dollars.

In the past, the occupants of family housing have been very cooperative in curtailing energy waste. These conscientious efforts have resulted in the Air Force meeting its conservation goals with no curtailment of services even with rapidly rising energy costs.

Even though you as an occupant of family housing do not receive individual utility bills, as a good citizen you will want to be a part of the Nation's energy conservation effort. In addition, because you may some day own your home and be paying utility bills, you probably wish to be knowledgeable and develop good habits concerning energy conservation.

One way in which you can contribute to substantial energy savings is simply to report promptly to the Base Civil Engineer any energy-wasteful condition which requires his attention (i.e., a broken window, etc.).

The energy-saving suggestions in this booklet are simple and can be applied at little or no cost. More important, we know they are effective. Many of the energy-saving devices needed for these improvements can be obtained from your Base self-help supply store.



Caulk around windows and doors.

Keep windows closed during the heating and cooling seasons.

YEAR-ROUND ENERGY SAVINGS

Several steps you can take will provide benefits in both summer and winter. In general, these measures help maintain indoor comfort, by preventing heat loss in winter and heat gain, or loss of conditioned air, in summer.

- Weatherstrip windows and doors at movable joints, and caulk cracks and openings at their frames; seal all cracks and openings in the exterior walls.
- Close and seal all openings into the attic from occupied space.
- Close off rooms and closets not in use.
- Keep windows tightly closed.
- Close window draperies during winter nights to reduce heat loss through windows and in summer to reduce solar radiation. In winter, you may want to open draperies on windows receiving full sunlight during the day to take advantage of solar heat, but close them again at night.
- Keep windows shut whenever the furnace or air conditioner are operating.

WINTER ENERGY SAVINGS

Once you have made sure that your house is well sealed, and that little heated air is being lost, other energy conservation steps can save still further on heating bills.

- Lower your thermostat. Each 1°F reduction in the setting of the room thermostat will save about 3 percent of fuel in cold climates and as much as 10 percent in moderate climates. If you set your thermostat back 10 degrees for an 8-hour period at night, you may expect to save 10 percent to 15 percent on fuel.
- Maintain an efficient heating plant. If your heating plant has an air filter through which the recirculated house air passes, clean or replace the filter frequently.
- Drain air or water from steam pipes and radiators, if applicable.

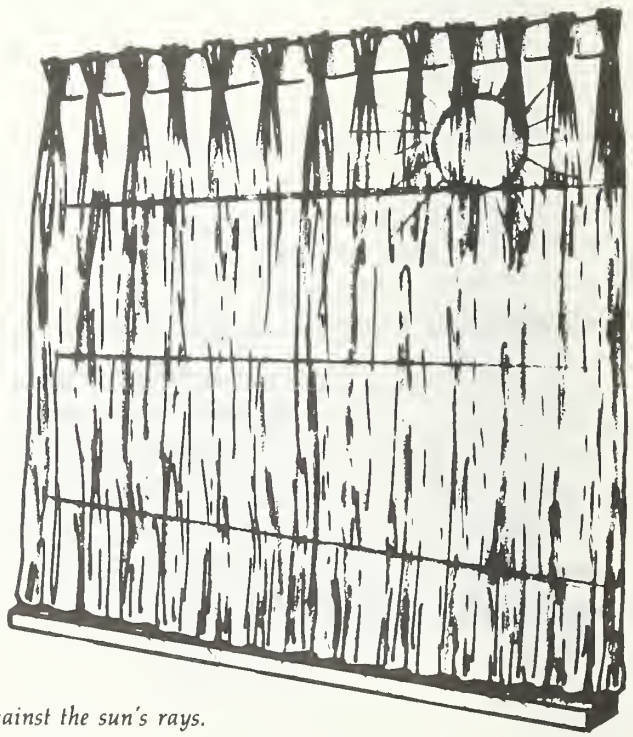
Move back thermostat 10°F at night.

SUMMER ENERGY SAVINGS

If you do not have air conditioning there are a number of things you can do to make your house more comfortable on hot days. If you do have air conditioning, many of these same measures can reduce the load on the air conditioning system, and so save energy.

- Dress lightly and raise the thermostat to highest level that will still provide comfortable indoor conditions.
- Make use of indoor and outdoor shading devices to reduce solar radiation through windows.

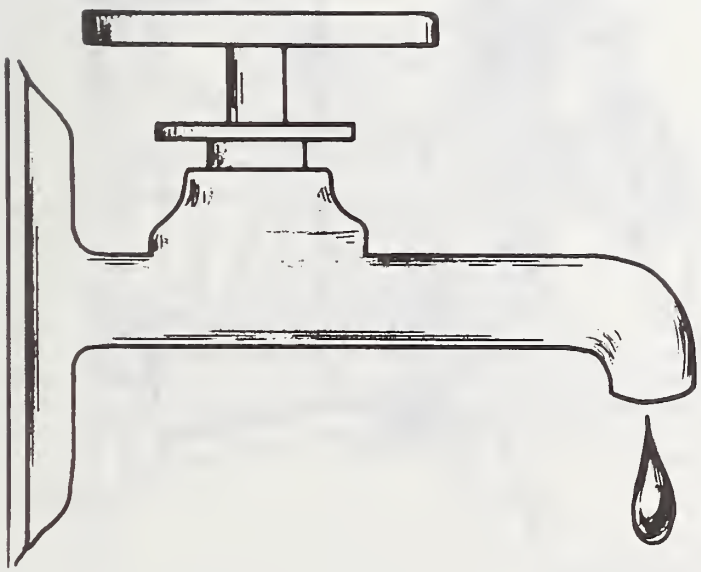
- Use hoods over stoves and use exhaust fans in the kitchen, bath, and laundry areas. Exhaust quantities of heat and moisture to the outside during periods when these areas of the home are in use.
- Whenever the outdoor temperature drops below 70°F and the outdoor humidity is not excessive, consider using outdoor air to cool the home instead of using the air conditioner. This may be accomplished by simply opening the windows; additional ventilation with outdoor air may be induced with a ventilating fan. When using a window fan, be sure to draw outdoor air from the coolest side of the house.
- Turn off television sets, radios, and phonographs when they are not being used. Schedule the use of electric ovens and ranges, and other electric appliances, during periods when air conditioning is not required. Reduce cooking operations.
- Turn off pilot lights of gas-fired heating plants during periods when space heating is not required. This can save 3,000 to 6,000 cubic feet of gas per year, depending on the length of your heating season. This fuel saving represents a monetary saving of $7 to $15 per year.
- Turn off air conditioning equipment during periods when house is unoccupied.



Use curtains to shield against the sun's rays.

SAVE ENERGY IN WATER HEATING

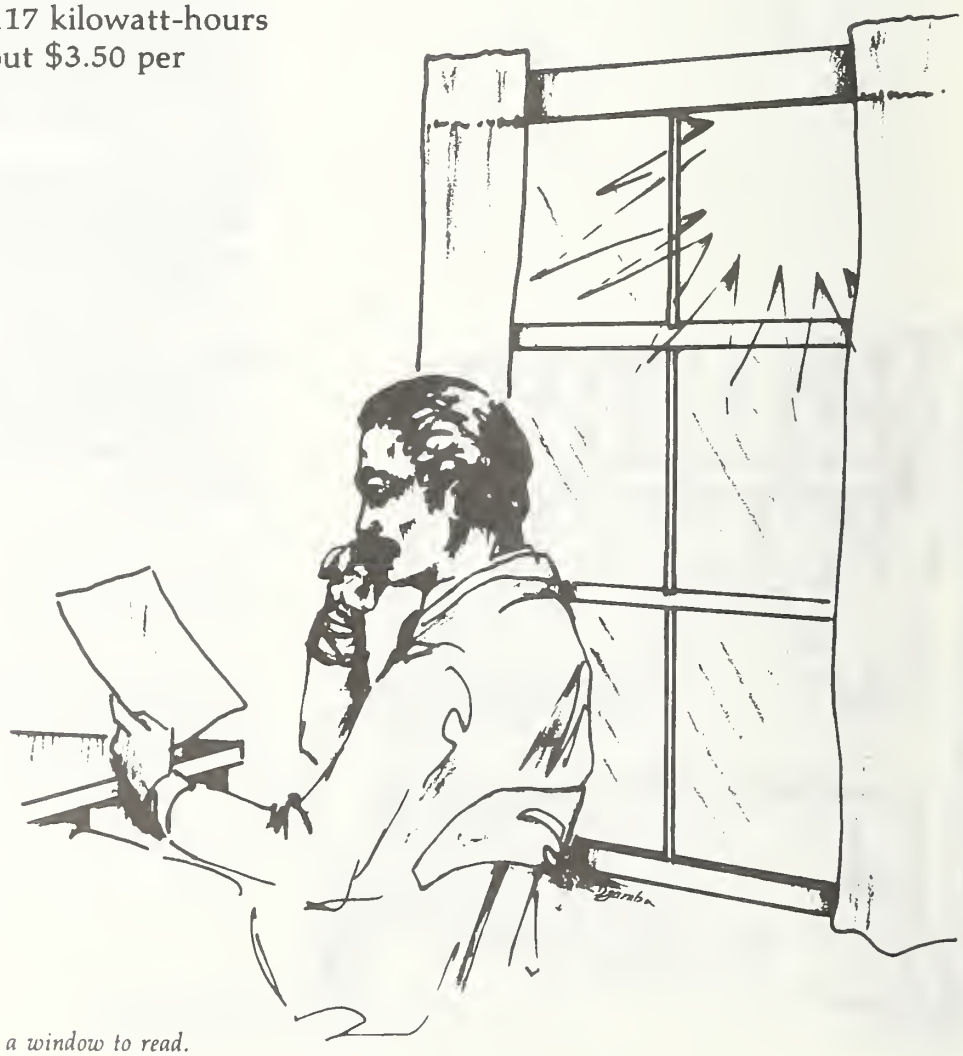
- Repair leaky faucets. A leak of one drop per second adds up to about 1.8 gallons per day or 650 gallons per year.
- Plastic flow inserts can easily be installed in shower heads to reduce the flow rate and thereby conserve water.
- Consider reducing hot water temperature to 120°F. When family-housing units are equipped with hot water heaters, often the supply temperature may be regulated by a simple control on the hot water heater. For a gas-fired hot water heater, reducing the temperature setting from 140 to 120°F can save as much as 1200 cubic feet of gas per year, a cost saving of approximately $29 per year.
- Reduce the operation of appliances that consume hot water by postponing operation of the appliance until the unit is fully loaded (i.e., dishwasher).
- Repair leaking toilets. A leaking toilet may lose as much as 20 gallons per day or 7,300 gallons per year.



Does it drip?

SAVE ELECTRICITY IN LIGHTING

- Turn off lights when not needed. However, it is not a good idea to turn fluorescent lights off and on if you leave the lighted area for only brief periods of time (up to 10 minutes or so). Repeated starting of fluorescent tubes shortens their lifespan.
- Use only the amount of light needed for specific room area and activities. Reduce general lighting. Provide a high level of illumination only where needed. For instance, replacing a 100-watt bulb that is used 8 hours a day with a 60-watt bulb will save approximately 117 kilowatt-hours per year, or about $3.50 per year.



Sit by a window to read.

SAVE ENERGY IN APPLIANCE USE

Clothes Washer-Dryer

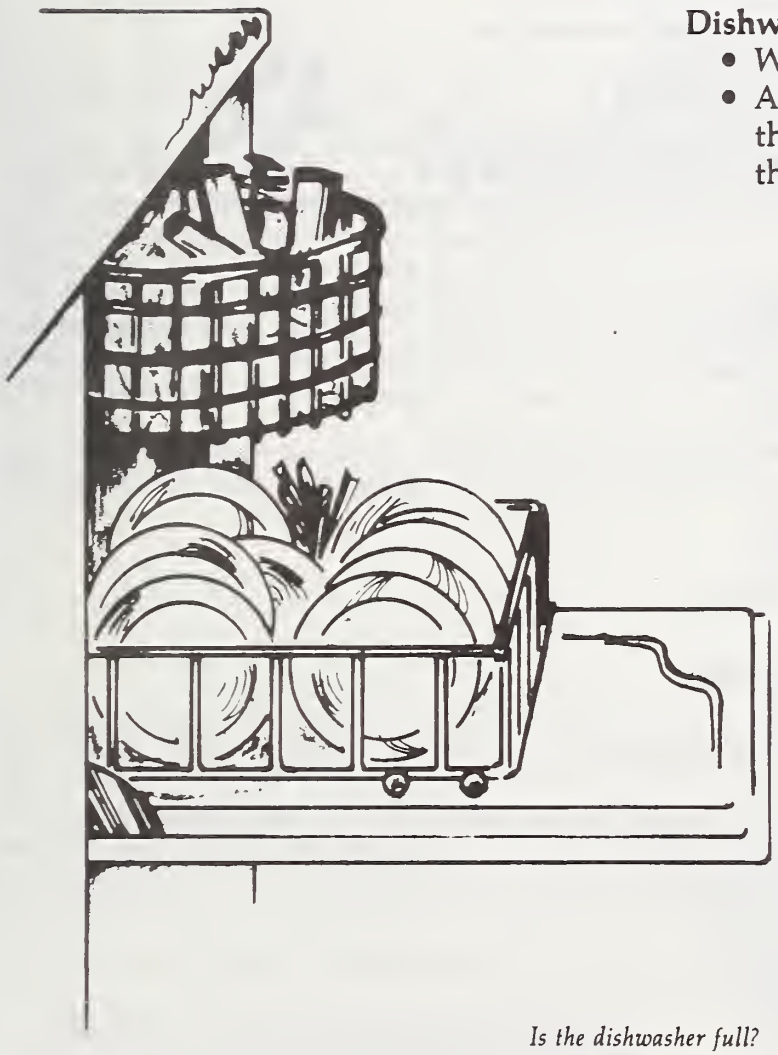
- Reduce frequency of use, especially when the air conditioner is on. Wash only full loads.
- Use cold or warm water settings in conjunction with cold-water detergents.
- Hang clothes to dry when the weather permits, instead of using clothes dryer.

Cooking Ranges

- Reduce cooking time when possible, especially when air conditioner is on.
- Cook several dishes or whole meals in the oven at same time.

Dishwashers

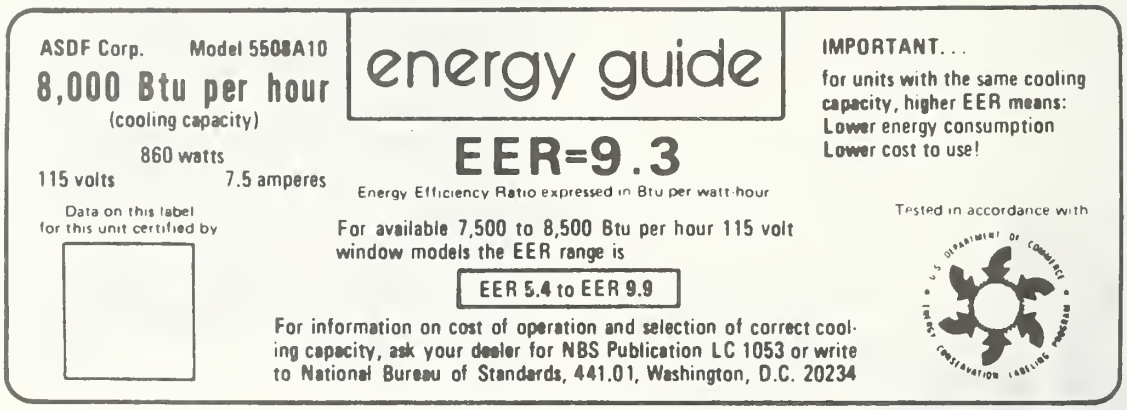
- Wash only full loads.
- Allow dishes to air dry rather than running dishwasher through the dry cycle.



Is the dishwasher full?

PURCHASING ENERGY-EFFICIENT APPLIANCES

Recently the Department of Commerce was involved in a voluntary labeling program as part of its overall energy conservation program. Participating room air conditioner manufacutrers, in conformance with the labeling program, now advertize their room air conditioners for sale with labels such as the one below:



The Energy Efficiency Ratio, EER, is a measure of the amount of cooling a room air conditioner can do relative to the amount of electricity it uses. The EER is determined by dividing the Btu-per-hour rating of a room air conditioner by the power in watts that it uses. Air conditioners with higher EER ratings are more efficient than those with lower EER's.

Room air conditioners were chosen as the first appliance group to be labeled with energy-efficiency information. Ultimately, labels are expected to appear on other energy-intensive appliances such as refrigerators, freezers, refrigerator/freezers, water heaters, dishwashers, clothes washers and dryers, kitchen ranges and ovens, central air conditioners, and comfort heating equipment.

Art work by Sue Dzamoa

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

General and specific guidelines to be followed by the USAF management personnel have been developed and tabulated in this Handbook. These guidelines include, for example, establishing management structures to implement the detailed energy conservation programs, analyzing alternative energy conservation options for most of the Air Force Base facilities, family housing units, and special buildings. The guidelines are to be helpful for establishing and implementing short- and long-range plans for energy management, gaining support of all Base and tenant personnel, and monitoring program progress. The Handbook covers such diverse topics as building survey, central plant identification, economic factor analysis, and human factors considerations.

The attached brochure is an illustrated handout for family-housing occupants, giving simple ways and means for saving energy in the home, or apartment.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Air Force facilities; building energy conservation; energy management; evaluation and monitoring; survey of buildings.

18. AVAILABILITY

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